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Research in
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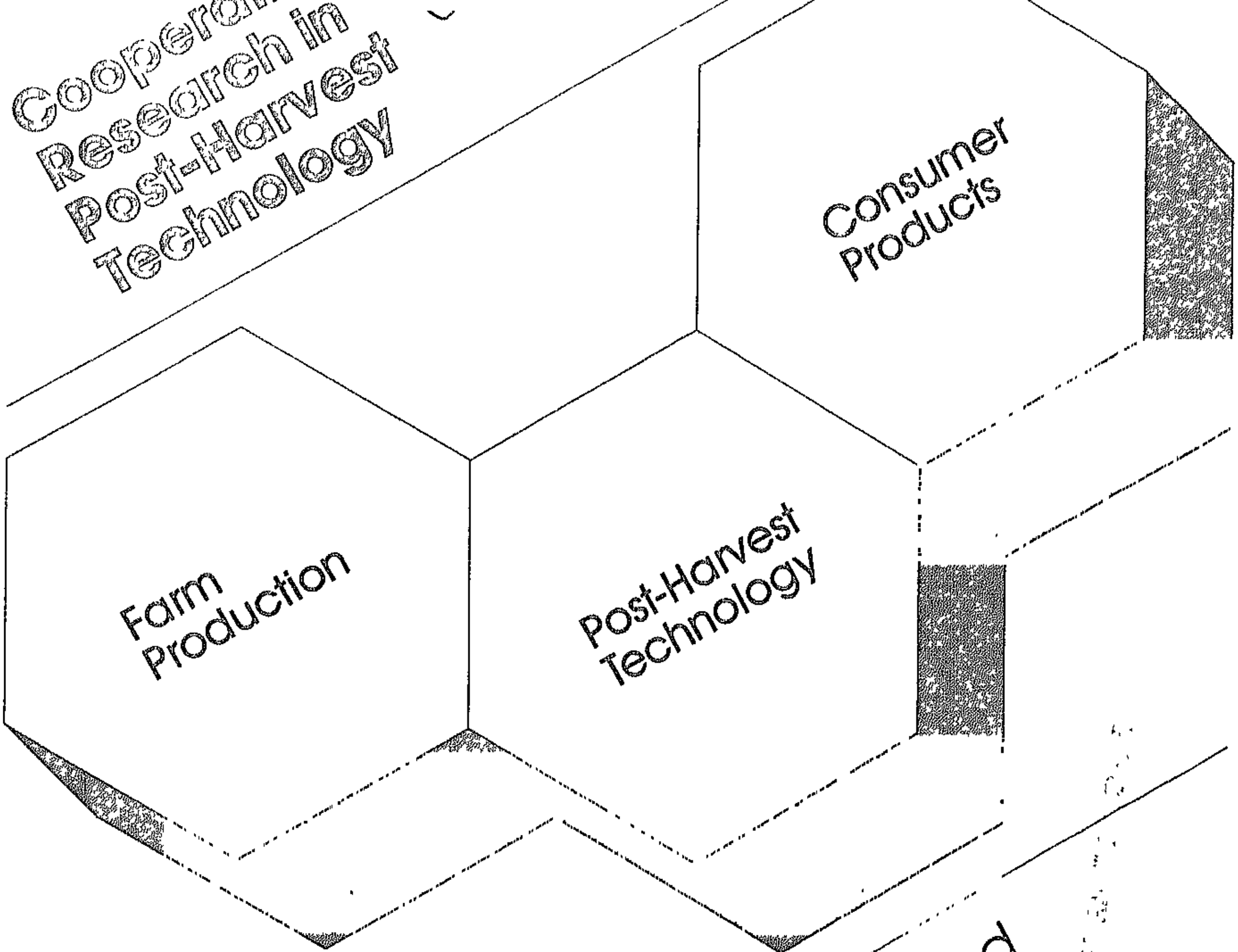

Solving Social and Economic Problems of the Food and Fiber Marketing System

U. S. Department of Agriculture

Science and Education Administration

ARM-H-3

COOPERATIVE RESEARCH IN POST-HARVEST TECHNOLOGY

SOLVING SOCIAL AND ECONOMIC PROBLEMS OF THE FOOD AND FIBER MARKETING SYSTEM

A REPORT TO THE
OFFICE OF MANAGEMENT AND BUDGET

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PREFACE

On July 12, 1977, the Director of the Office of Management and Budget (OMB) sent a letter to the Secretary of Agriculture requesting that the U.S. Department of Agriculture review its marketing research programs. The purpose was to assure that USDA is doing only research not otherwise being done by the private sector.

Agricultural Research (AR), in the Science and Education Administration (SEA) of the USDA, was assigned the lead responsibility in making a study of the Post-Harvest Technology (PHT) Research within the overall marketing research program. Cooperative Research (CR), also a unit of SEA, was assigned to assess that part of the PHT Research that is carried out with Federal funding in the various States and territories of the United States. This report provides the results of the CR assessment. The report covers research done with Hatch funds, McIntire-Stennis and other Federal funds allocated to the States by Congress as well as State appropriated funds and industry grants.

[Note:] This report represents the combined efforts of many persons; including CR administrators, State agricultural experiment station directors, department chairmen,research scientists and SEA/CR staff. Preparation and assembly of the report was done by R. A. Dennison and R. G. Garner. Its purpose is to provide information on the status of the post-harvest technology program and thereby complement the SEA/AR study. Coordination with the SEA/CR study was primarily through the assistance of H. S. Ricker, Chairman of the AR Agricultural Marketing Research Institute at Beltsville, Maryland. Evaluation procedures and format were designed to be complementary to the SEA/AR study in that both programs, although distinctly different, are related to the same set of socio-economic goals. Access to the study plan developed under the leadership of A. M. Cowan, Staff Scientist for Industrial Processing Technology of the National Planning Staff, Room 215, Building 005, BARC-West, Beltsville, Maryland, is acknowledged. The extensive descriptive information regarding the food and fiber marketing system provided in SEA/AR's report "Post-Harvest Technology Assessment," Volume II was shared and drawn upon but is not included with this report.

Highlights

Review and analysis of State and other client institutions research programs in post-harvest technology (PHT) indicate that:

1). A total of $59.2 million and 831.5 scientist years (SYs) were devoted to these programs in FY 1976.

2). The research addresses high priority problems related to key socio-economic goals as well as provides information in support of regulatory functions and generates essential basic knowledge.

3). A strong PHT research program is essential to the continued proper and efficient functioning of the food and fiber marketing system and for the technological developments on which its future rests.

4). Publicly supported PHT research programs help (1) bridge the gap between agricultural production and consumer demands, (2) small, local organizations which serve society and provide employment but are too small to conduct research; and, (3) protect the public interest in matters of safety, quality, supply and cost of agricultural products.

5). The PHT research programs are jointly planned, funded and implemented by university, government and industry to prevent unnecessary duplication.

6). Responsibility for conduct of PHT research is shared by university, government and industry; some areas are the clear responsibility of the university, some are the clear responsibility of government, others are the clear responsibility of industry, and in some areas it is appropriate for the responsibility to be shared.

7). Scarce total resources dictate careful attention to appropriate roles and responsibilities.

8). Since it is not reasonable to expect private industry to undertake PHT research that is clearly the responsibility of the public sector, research in the public interest would not necessarily be undertaken by industry if public funding were withdrawn.

9). In general, the State and OCI research effort in PHT is within the scope and context considered appropriate for publicly supported research.

10). While the cost-benefit ratio is difficult to determine due to the complexity and variability of the PHT system, the probability for high payoff is considered great.

This report analyzes the PHT research effort carried out by the land-grant institutions, the State agricultural experiment stations (SAES) and other client institutions (OCI). The Science and Education Administration-Cooperative Research of the USDA administers the Federal Hatch and other funds allocated to these institutions for support of this work.

An assessment of post-harvest technology research for the food system is primarily the consideration within this report. However, data are also included on the post-harvest technology research effort supporting developments for wood and fiber products resulting from agricultural production.

Assessment of Post-Harvest Technology Research Administered by Cooperative Research

Contents

INTRODUCTION

Consumers expect an adequate supply of high quality, safe, wholesome, and nutritious food and farm products in the form that they desire and at a reasonable cost. The United States has had to develop a well-functioning, total food system to reach the present stage of efficiency and the capability to meet these consumer expectations. Almost every other country marvels at the success of the United States in this endeavor.

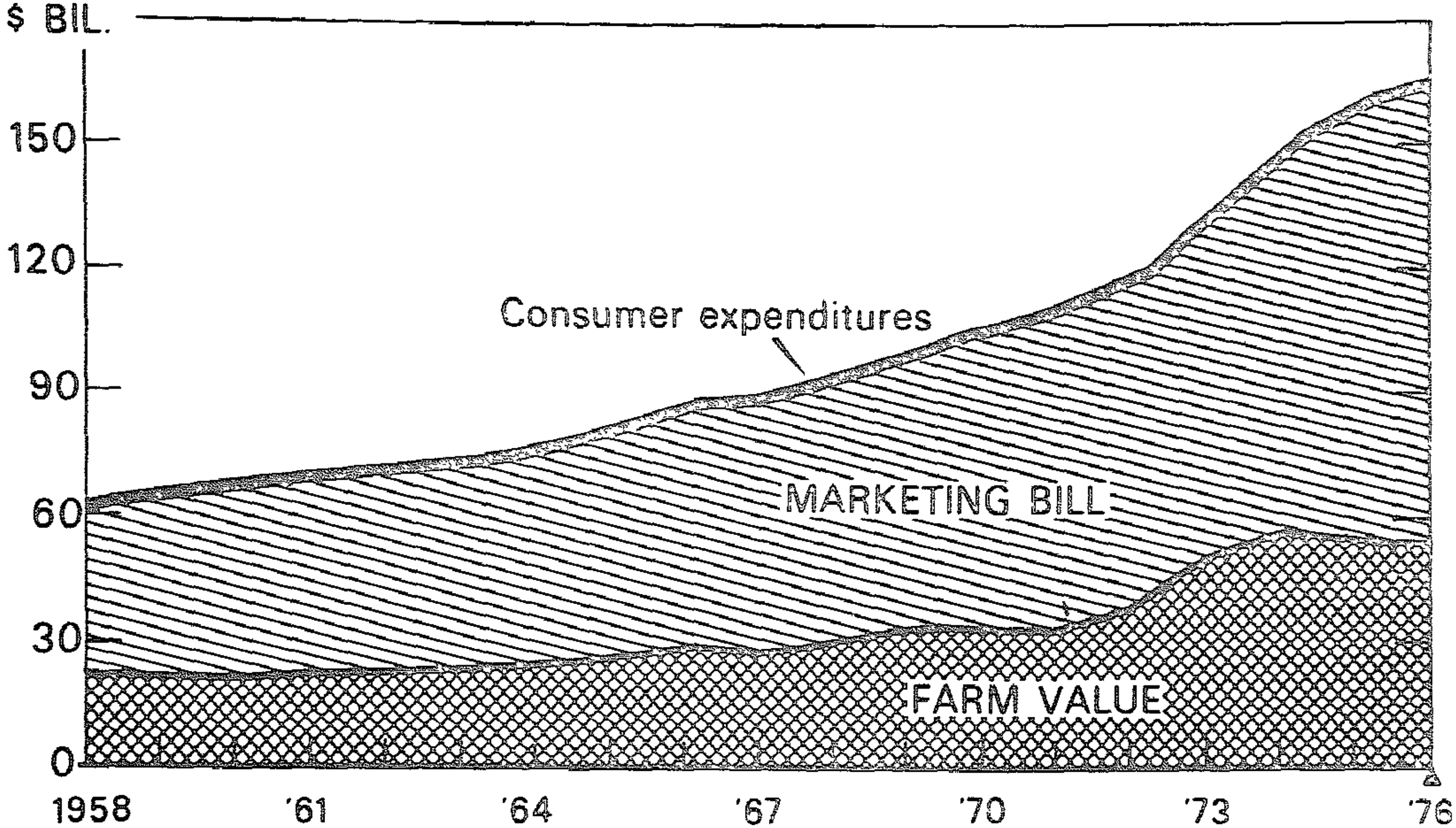
The food and fiber system includes all of the functions from the farm production of the raw materials until the final products are obtained by consumers. The marketing segment of the system includes those activities performed from the time materials leave the farm gate until they reach consumers. There are two major components to marketing activities: those identified with the "technology" of marketing, and those identified with the "economics" of marketing. Post-harvest technology encompasses the technology aspect which includes the functions of assembly, processing, packaging, warehousing, storing, transportation and distribution of agricultural products through the institutional food trade, wholesale and retail outlets.

In 1976 consumers spent an estimated $180 billion for food of farm origin. Approximately one-third of the expenditures were farm production costs and two-thirds food marketing costs. Major concerns are voiced by many groups about food costs and particularly the percentage of the costs attributed to the marketing segment within the food system.

In the United States consumers have higher expectations concerning food today as compared with yesterday. Consumers will expect even more tomorrow. This is substantiated by the demands for a safer food supply, for products that provide greater nutritive value, for quality assurance, for products in a condition for convenient storage for later use, for products with a minimum of loss or no waste during preparation, and for products that are in a convenient form for use. In addition society is expecting that the industrial operations required for the production of the food supply in this condition will be accomplished without causing pollution of the environment, without placing undue demands on energy requirements, and at minimum cost.

In order to meet these expectations, it is necessary to have a continuing research effort. The question is who should be responsible for the research in the post-harvest technology area? Is this the responsibility of the private sector and those industries directly involved? Should the research be carried out primarily by the Federal government? Or should the support of the research and the technological developments be a joint responsibility of the land-grant institutions in the 50 states and the territories of the United States, the Federal government and the industries involved?

FARM-FOOD MARKETING BILL AND CONSUMER EXPENDITURES



FOR DOMESTIC FARM FOODS PURCHASED BY CIVILIAN CONSUMERS FOR CONSUMPTION BOTH AT HOME AND AWAY FROM HOME. ΔPRELIMINARY

USDA

NEG ERS 961-77(2)

Government at the National, Regional, State and local levels has many responsibilities to society in assuring adequate safe, wholesome and nutritious food supply at a reasonable cost. As consumers demand more and more knowledge and information about foods, it is necessary to have increased data on the composition, the nutritional values and bioavailability of nutrients. There must be better understanding of food safety and influences on health. The measurement of food quality must be refined so that there can be better control through grades and standards. The environment must be protected by using better technology with the various operations required for the food system. Since the multitude of operations require a large percentage of the total energy, new technology must be developed that will conserve energy, the use of new energy sources, and reduce energy requirements. These societal problems must be solved by new and improved technological developments. Both government and private industry must contribute to this effort.

In the following sections of this report, the scope and accomplishments of the post-harvest technology research program will be analyzed with consideration of the contribution to socio-economic goals. The Cooperative Research effort is primarily carried out through the State agricultural experiment stations, the schools of forestry, the land-grant universities, the 1890 universities and Tuskegee Institute. Since these units receive support in addition to the Federal funds administered through Cooperative Research, this additional research effort applicable to post-harvest technology will be reported also.

[illegible]

	Establishments			All Employees					
	Dept. of Commerce Code	Total (Number)	With 20 Employees or more (Number)	Number (1000)	Payroll ($million)	Value Added by Manufacture ($million)	Cost of Materials ($million)	Value of Shipments ($million)	Sales ($million)
Food and Kindred Products	20	28,184	12,326	1,569.4	12,921.9	35,616.6	79,800.0	115,060.4	(NA)
Wholesale Groceries and Related Products	514	38,531	(NA)1/	(NA)	4,833.7	(NA)	(NA)	(NA)	106,457.3
Retail Food Stores	54	267,352	(NA)	1,722.5	8,820.2	(NA)	(NA)	(NA)	100,718.9
Eating and Drinking Places	58	359,524	(NA)	2,634.5	8,735.0	(NA)	(NA)	(NA)	36,867.7
Totals		693,591	12,326	5,926.4	35,310.8	35,616.6	79,800.0	115,060.4	244,043.9

1/ Not available or not applicable

COOPERATIVE RESEARCH AND THE REGIONAL AND NATIONAL AGRICULTURAL RESEARCH PLANNING SYSTEM

A. Legislative Authorization

A unique partnership between the Federal Government and the States with regard to agricultural research has continued for 116 years. In 1862 President Abraham Lincoln signed into law two acts which initiated this partnership: (1) "an act establishing the U.S. Department of Agriculture" (May 15, 1862), and (2) "an act donating public lands to the several states and territories which may provide colleges for the benefit of American Agriculture and the Mechanic Arts" (July 2, 1862).

The Hatch Act--which became law on March 2, 1887--provided Federal-grant funds for research, produced the land-grant colleges, agricultural experiment stations and, in the process, initated Federal-State cooperation in agricultural research. Subsequent acts provided additional Federal funds to strengthen and expand these programs.

Modern-day agriculture in the U.S. reflects the influence of almost a century of effective cooperative research between the land-grant colleges and the U.S. Department of Agriculture. This joint system for agriculture and forestry research has provided the technical base upon which the U.S. food and fiber system has been built. Federal-State cooperation has proven to be the most effective, efficient and productive method for providing food and fiber of any in the world. The system has been and is being copied by many other nations.

B. The Research System in the USDA, States and Territories

The research system involves six USDA agencies, 56 State agricultural experiment stations, 61 schools of forestry, 16 land-grant colleges of 1890 and Tuskegee Institute. It provides for an effective research effort in every State plus the District of Columbia, Guam, the Virgin Islands and Puerto Rico and makes it possible to respond quickly to local, regional and National problems. The system is highly organized and coordinated. Both the individual scientists and the administrators can be used in project and program development and coordination. A Director of a State agricultural experiment station is aware of the needs within the State as well as regional and national needs.

C. Research Funding

The nationwide system for agriculture and forestry research makes it possible to have a wide base of financial support. Federal funding is essential; but in addition State governments, industries, foundations, private organizations and other governmental organizations provide support. Research funds administered by the USDA can be categorized as intramural, extramural and "pass through". Intramural funds for research are those used for USDA programs principally performed by USDA employees. Agricultural Research (AR) will report on PHT programs supported by the intramural funds. Extramural funds are those appropriated to USDA, administered by USDA, but intended for research at institutions and by scientists outside of USDA. Most of the USDA extramural funds are administered by Cooperative Research (CR). Pass-through funds are those appropriated to one Federal agency and then "passed through" to another Federal agency for administration.

Cooperative Research (CR), through the Science and Education Administration (SEA), is the USDA agency responsible for working with the State agricultural experiment stations (SAES), the colleges of 1890, the forestry schools and other cooperating institutions to help foster research cooperation and coordination. CR administers the extramural funds appropriated by Congress under the Hatch Act, the McIntire-Stennis Act, the Experiment Station Facilities Act, the Act for Colleges of 1890 and Tuskegee Institute, and the Rural Development Act. The agricultural research programs at these institutions are not only supported by the extramural funds, but also by State-appropriated funds, industries, foundations, private organizations and other government organizations. In 1976 the CR-administered funds supported 19 percent of the total program for agriculture research as shown in Table 2. Thirty-one percent of the support for post-harvest technology research came from CR-administered funds.

The 1976 agricultural research funds by sources and manpower for each of the four regions in the United States are given in Table 3. Table 4 gives the 1976 funds and manpower assigned for PHT research. Of the total agricultural funds and manpower, approximately 10.9 percent and 12.6 percent, respectively, were used for PHT research.

Table 2. Percentage of the funds from various sources supportin the overall agriculture research programs and PHT research, 1976

Source of Funds	Agriculture %	PHT %
Extramural funds administered by CR	19.4	31.2
Other Federal Agencies	7.5	8.0
State Appropriations	57.2	50.2
Industry Grants	5.2	5.6
Other	10.7	5.0
Total	100	100

D. Research Planning and Coordination in the System

The total system for agriculture and forestry research is well planned and coordinated. There is a National Planning Committee which establishes guidelines for national and regional planning operations. The Committee is composed of administrators of the major USDA research agencies and directors of the State agricultural experiment stations. The Committee may appoint special subcommittees to plan research programs which are nationa or multi-regional in nature.

There are four regional planning committees: Northeastern, Northcentral, Southern and Western. The Committees include designated USDA regional administrators, directors of State experiment stations and representatives of the 1890 colleges. Each Regional Committee may appoint one or more working groups to deal with distinct subject matter areas which are identified under seven research program groups (RPG's). Within the RPG's are the identified research programs (RP's) and planning units can be organized for these. The RP work units are commonly referred to as the task forces. They are mostly comprised of the scientists plus administrative advisors.

The research planning and coordination system is of great value. Taxpayers realize needed accomplishments at a reduced cost because of good planning. The identification of problems and setting of priorities is improved. There is better interaction among scientists and more rapid implementation of the research for the benefit of consumers.

Table 3. Total Funds and Manpower for SAES, Forestry Schools and OCI, 1976. 1/

Region	Source of Funds ($1,000)						Scientist Years
	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	
Northcentral	27,341	15,674	79,473	9,647	111,720	154,735	1661.2
Northeast	17,729	5,716	34,889	2,978	45,287	68,732	934.9
Southern	43,166	5,841	114,720	8,461	140,089	189,096	2374.8
Western	16,531	13,603	80,651	7,185	98,559	128,693	1637.5
Total	104,768	40,834	309,733	28,271	395,655	541,257	6608.4

1/ Inventory of Agricultural Research FY 1976, Vol. II

Table 4. Funds and Manpower for PHT Research, 1976

Region	Source of Funds ($1,000)						Scientist Years
	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	
Northcentral	4,943.9	2,137.6	7,214.8	1,234.1	9,913.0	16,994.5	211.8
Northeast	3,366.2	640.3	4,022.9	471.9	4,913.9	8,920.4	138.9
Southern	7,298.8	636.8	10,260.7	645.6	11,497.3	19,432.9	286.1
Western	2,821.8	1,322.5	8,191.6	990.9	9,656.8	13,801.1	194.8
Total	18,430.6	4,737.2	29,690.0	3,342.5	35,981.1	59,148.9	831.5

Of particular interest with regard to the assessment of Post-harvest Technology Research is the work of three regional task forces during the mid 1970's. Task forces in the Northcentral, Southern and Western Regions made studies of some of the neglected technological problems and priority research needs for the marketing sector of the food system. These task force reports relate to much of what is encompassed under the definition of post-harvest technology research. Following is a summary, by regions, of areas the task forces identified as priority research needs:

A. Northcentral Region

I. Food losses

II. Underutilized resources

III. New sources of food

IV. Nutritional quality of food

V. Processing efficiency

VI. Food safety

B. Southern Region

I. Raw product quality requirements for fresh and processed foods

II. The technology of new and improved food products and processes

III. Maintenance and protection of food quality during processing, storage, and distribution

IV. Food acceptance and consumption

V. Storage, distribution, and marketing systems for food

VI. Evaluation and maintenance of nutritive values of foods

VII. Processing, preparation, and delivery of foods for convenience or institutional use

VIII. Energy, water and waste management in food handling and processing

IX. Methodology and assessment of quality attributes for grades and standards of foods.

X. Assessment of effects of science and technology of food on health, environment and socio-economic factors

C. Western Region

I. Food safety

a. Mycotoxins
b. Naturally occurring toxicants
c. Microbiological hazards
d. Safety of new or alternate food sources

II. Food composition and nutrient availability

a. Effects of processing, transportation and storage on composition
b. Effects of institutional food service handling and food preparation procedures on nutrient retention
c. Improved analytical methodology
d. Dietary patterns and food intake
e. Determination of nutritional status
f. Bioavailability of nutrients
g. Mineral and fiber fortification technology

III. Consumer acceptance

a. Impact of regulations on productivity and ultimate food costs
b. Food quality relationship with new plant varieties and animal breeds
c. Improved methods for measuring quality
d. Improved methods for detecting environmental contaminants

IV. Utilization of new technology for quality improvement

a. Bulk handling of raw materials
b. Processing
c. Reprocessing and materials conversion
d. Post-processing storage

The organization by regions provides for an easy and rapid method to bring about concerted team effort when a problem arises that is of interest to two or more States. If agreed upon by the Directors within the region the research can be supported by Regional Research Funds (RRF) which are made available under the Hatch Act (PL 84-352). The participating scientists in a regional project are responsible for accomplishing the objectives and working within a regional research committee.

Some of the regional projects have made and are making important contributions to the area of post-harvest technology. The following are examples of regional projects with particular significance to PHT research:

NC-132 - Market Quality In Wheat

This regional project brings together the special skills of a number of cereal scientists in the Northcentral Region and focuses these skills upon the complex problems of what constitutes good market quality of wheat. It is necessary to understand the biochemical and physical characteristics of the wheat kernel and its components, and how these effect the "quality" of wheat and wheat products. It is also necessary to know the causes of changes in "quality" induced by environment, storage conditions, milling and processing practices.

NE-116 - Quality Maintenance and Control in the Marketing and Storage of Vegetables

This regional project provides the mechanism whereby scientists in the Northeast Region bring to bear their talents on the development of methods and instrumentation for measurement of quality in vegetables and in applying these methods in the development of improved marketing practices. The work may involve objective measurement of color, texture, nutritive value, defects or physiological disorders of vegetables or establishing storage requirements or conditions for storing certain vegetables that maximize nutrient retention and sensory quality.

S-101 - Factors Affecting the Purchase and Use of SweetPotatoes

The purpose of this regional study is to determine consumer attitudes toward sweetpotatoes and sweetpotato products; to describe the internal and external quality of sweetpotatoes and sweetpotato products and to relate these to consumer preferences;

and finally, to establish reliable product quality guidelines to help the industry more completely satisfy consumer demands and thereby assure growth of the sweetpotato industry. Factors affecting the purchase and use of sweetpotatoes have been identified and this information is being used to guide further research.

From the above examples, it is possible to see the efficiencies and advantages of regional projects. Regional problems of concern to an entire industry or region may be undertaken more efficiently by coordinated rather than independent actions. Advice and support may be obtained from interested parties, such as producers, regulatory agencies, processors and consumers.

Regional research resolves by team effort problems too large for a single station or agency to attempt to solve. Because regional research brings together highly competent scientific talent from experiment stations and Federal agencies, both the solutions of problems and the applications of results occur much more quickly than by isolated effort. At the same time, the regional approach has helped to avoid the costly duplication of similar research at more than one location.

Those who do the actual work on regional projects - the scientists themselves - are quick to point out that their involvement under RRF is a stimulating experience because it brings them in close contact with others having like interests and goals. The mutual exchange of information and ideas invariably pays off.

Two unanticipated advantages have added considerably to the merit of the program. Regional projects provide increased opportunity for concentrating research competence and funds on problems at locations where there is a high potential for significant progress. Secondly, the RRF program has an enviable record of stimulating young scientists to become more competent and responsive in their fields.

E. Research Coordination with Extension and Teaching Activities at the Land-Grant Institutions

There also are unique ways for the delivery of the new knowledge from research to the users. At the land-grant institutions the extension specialists in the cooperative extension service take the research results directly to the people, those who can benefit most from its use. Almost every county has extension personnel working directly with consumers, industry groups, cooperatives, local, State and Federal Government agencies. Consumers are made aware of

new knowledge that has come from research relative to nutritive values of various foods, safety, and quality factors. Small food companies generally do not have the available capability to translate new knowledge from research into applications for improvement of their operations. But through the educational programs carried on by the extension specialists there is a much earlier adaptation of new knowledge. Also, government agencies have direct contact with the extension specialists and the universities for a source of current information and new developments.

The research programs at the land-grant institutions are normally closely associated with the teaching programs, both at the undergraduate and graduate levels. Usually the scientist has an appointment carrying responsibility for both research and teaching. This is extremely valuable for the training of well-qualified personnel to fulfill the future scientific and technical needs of government agencies, academic institutions and industries. During the time of the training program at the graduate level, students are usually involved with the research projects. They are making contributions and helping to add data for the various scientific fields.

The payoffs from the Cooperative Research-Agriculture Research system have been enormous and are one of the reasons this Nation spends less of its disposable dollars for the purchase of food than any other country.

ANALYSIS OF THE PHT PROGRAM BY SOCIO-ECONOMIC GOALS AND RESEARCH ACTIVITIES

A. Classification of the PHT Research by Goals

There is increasing awareness that developments and concerns within society as a whole must be a major focus for publicly supported research efforts. The judgment of the importance of programs cannot be evaluated for just one segment of society. A determination of the benefits to the public at large must be made.

Post-harvest technology research for the food and fiber system relates to a number of societal concerns. These concerns include the decisions on energy use, protection of the environment from pollution, maintenance of health, maintaining the costs for food and fiber at a reasonable level, and others.

The Office of Management and Budget (OMB) and SEA-AR identified seven socio-economic goals under which to allocate the effort of the PHT research projects and to assess their contribution:

Goal 1 - Energy and Renewable Resources

Goal 2 - Environment

Goal 3 - Productivity

Goal 4 - Reduction of Losses

Goal 5 - Health and Safety

Goal 6 - Product Quality

Goal 7 - Balance of Payments

In addition to the socio-economic goals, OMB asked for an indication of the percentage of the research effort directed to the support of regulatory and action agencies (Goal 8) and the percent of the research classified as basic (Goal 9). Goals 8 and 9 are considered non-additive and therefore are not included in the allocation of the 100 percent project effort for the socio-economic goals.

Following is a brief description of each of the goals:

1. Energy and Renewable Resources (Goal 1) - The development of methods, processes and techniques for (1) the conservation of energy, (2) the use of alternative sources of energy and (3) the improved management of energy.

2. Environment (Goal 2) - Pollution reduction in the water, soil and atmosphere through new processing technology, waste management and use of biodegradable materials.

3. Productivity (Goal 3) - Development of new and improved technology and methods for processing, distribution and marketing in order to increase efficiencies, reduce overall marketing costs and improve competition.

4. Reduction of Losses (Goal 4) - Development, improvement and/or adaptation of technologies for the prevention or reduction of product losses caused by microbial contamination, insects, rodents, birds, adverse physiological changes and mechanical damage.

5. Health and safety (Goal 5) - Identification of potential hazards to health and safety resulting from food or the work environment and the development of methods for the elimination, control or reduction of the degree of hazard.

6. Product quality (Goal 6) - The development of technology for the maintenance of optimum quality and acceptability for products, including the sensory, nutritive and convenience factors - and the improvement of methodology and instrumentation for measuring and assessing quality.

7. Balance of Payments (Goal 7) - The development and adaptation of new and improved technology that will add value to commodities for the export market and provide methods for expanding the export market.

8. Support of Regulatory and Action Agencies (Goal 8) - Research undertaken in direct support of an action or regulatory agency.

9. Basic Research (Goal 9) - Research undertaken to test new hypotheses or theories and to obtain an additional base of knowledge.

In order to assign the research to goals it was necessary to use a classification scheme. Information on agricultural research projects is maintained in the USDA Current Research Information System (CRIS). The Manual of Classification of Agricultural and Forestry Research is used by CRIS for classifying research. The research "Activity" describes the nature or the type of research involved. The "Research Problem Area" (RPA) describes the field of the research the projects are identified with. Using the two dimensions of Activity X RPA, the research effort for goals 3 through 7 was obtained through CRIS printouts. Table 6 in the Appendix provides the information on the Activities and RPAs used for each goal. The funding, source of funds and scientist-years (SY's) were available from the printouts.

Goals 1 and 2, Energy and Environment, could not be classified by the two-dimensional scheme. It was necessary to use keywords and select the projects contributing to PHT research as defined under these goals. From the projects listed under the keywords "energy" the selection was made of projects contributing to goal 1. Checking under the keywords "processing-waste" and "waste" the selection was made for the projects contributing to goal 2. Using the accession number for the projects selected, the data on funding, source of funds, and scientist-years were obtained.

The research effort contributing directly to the work of the regulatory and action agencies (Goal 8) was obtained by using the two-dimensional scheme of the Activity 5800 X the RPAs 501 and 512.

The amount of research effort classified as basic research (Goal 9) was obtained from the information for each project contained on the USDA AD Form 417. The scientists list, in field 32 of this form, the percentage of the research that is basic for each project.

In addition to evaluating the PHT research by the socio-economic goals the total program has been analyzed by research activities as defined in the USDA Manual of Classification of Agricultural and Forestry Research.

B. Impact of Programs Upon Socio-Economic Goals

Table 5 shows the total funding and manpower for PHT research. The funding includes that appropriated by Congress to USDA and administered by CR, contracts and grants from other Federal agencies, State legislative appropriations, the industrial grants and total non-Federal funds. The non-Federal funds include product sales in addition to the State-appropriated and industry grant funds.

Considerable variation was found in the proportion of the support for each socio-economic goal that came from CR administered funds. For the environmental goal only 15 percent of the funds came through CR, while 38 percent of the funds for the balance of payment goal came through CR. The reduction of environmental pollution and maintenance of environmental quality has been a major concern in most every State for several years. As would be expected, a greater proportion of State funds is supporting the efforts to find solutions to the critical environmental problems. On the other hand the seriousness of the balance of payment problem has been of more recent concern to society, and the overall solution of the problem is identified more with national efforts and policies.

It will be noted that for every socio-economic goal the funds appropriated by the States exceed those appropriated by Congress and administered through CR. The fact the States provide the major support indicates their willingness to work closely with the Federal Government in finding solutions to the societal problems related to post-harvest technology. Industry is also making some grants to the State institutions for supplemental support of research under every goal because of their interest in obtaining solutions to the critical problems.

The research on the production of agricultural raw materials is closely coordinated with the post-harvest technology research at the State agricultural experiment stations and land-grant institutions. Production of the raw materials is the first-step in the system for getting food to the consumer. The ultimate quality, nutritive value, wholesomeness and freedom from contaminants starts with the raw materials. Some of the major efforts in PHT research are bridging agriculture production to the consumer needs.

Over one-half of the total PHT research effort is supporting the goal for productivity. This should be expected since consumers are demanding new types of products and increased efficiencies to keep marketing costs as low as possible. T second largest program is for product quality. Consumers will not purchase products unless they have esthetic appeal, meet nutritive requirements and are convenient for use. The research directed toward maintenance of safety and health is third in the order of support. Only in recent times has there been recognition that food, fiber products and the working environment can present a number of potential hazards for society.

Table 5. PHT Research by Socio-Economic Goals

Funds and Manpower Assignment for FY 1976

Goal	Source of Funds ($1,000)						Manpower
	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	Scientist Years
Energy	202.5	91.0	370.1	60.3	441.1	734.6	8.7
Environment	195.0	235.5	726.2	47.7	851.5	1,281.9	14.0
Productivity	10,107.3	2,177.2	15,040.2	1,867.6	18,493.5	30,778.0	468.3
Loss Reduction	400.9	18.7	827.5	63.6	959.8	1,379.4	18.0
Health & Safety	2,889.3	1,549.5	4,853.0	485.7	5,591.1	10,029.9	128.4
Product Quality	4,251.6	583.0	7,382.6	806.2	9,091.1	13,925.8	178.4
Balance of Payment	384.0	82.2	490.5	11.4	552.9	1,019.2	15.7
Total	18,430.6	4,737.2	29,690.0	3,342.5	35,981.1	59,148.9	831.5

Particularly during the past decade the greatest pressures were on increasing production to meet world food needs. Recently other food-related problems have evolved that are of major concern to society. These include food losses, environment, energy and balance of payments. By 1976 PHT research scientists had studies underway to obtain data and develop information to help solve these problems. There are studies that seek methods for reducing losses resulting from spoilage, contamination, physical damage and deterioration of quality. Damage to the environment has resulted from production and distribution procedures used in some of the food industries. In many cases new technology is needed to correct the problems. Energy conservation and new sources of energy are a necessity for many of the industries. Current studies in foreign marketing are looking at methods for expanding demand for U.S. food products and commodities. Improvement in the balance of payments is dependent upon increasing the demand for products.

A brief analysis of the situation for each of the socio-economic goals is given in the following materials. In the Tables 6 to 12 data are presented for each region on the funding and manpower support.

GOAL 1. ENERGY AND RENEWABLE RESOURCES

Problem and Social Impact

The "Energy Crisis" has attracted the attention of the many industries involved in the food chain from production to consumption and has led to the recognition that changes must be made. Inadequate supplies and the rapid increase in costs for energy have a real sense of urgency for new developments.

Approximately 17 percent of the total United States energy requirement is used in the food and fiber system. About one-third of this energy is required for the food processing industries. Additional energy is required for the transportation, storage, wholesaling and retailing of products. It is readily apparent that these industries are vulnerable to energy shortages. They are genuinely interested in new technology for energy conservation.

Energy costs are a major factor contributing to increasing costs of food. It is highly important to develop new technologies that will help reduce the energy demands and make for more efficient operations in the industries involved with the post-harvest technology. The feasibility of using non-traditional energy sources as well as increased efficiencies with conventional sources must be researched.

Current Program

Energy research is not classified as such in the CRIS system. The 1976 research projects contributing to this goal were identified through the list of projects appearing under the keyword "Energy".

Table 6 shows that in 1976 the State agricultural experiment stations had 8.7 SY's with an expenditure of approximately $0.75 million on energy research in the PHT area. The Northcentral region of the country was devoting more effort to energy research than the other regions. Except for the Southern region, the States were investing more than twice as much funding for PHT energy research as was used for this area from Hatch funds. In 1976 the research related primarily to seeking methods for reducing energy demands in the processing and storage of fruits, vegetables, field crops and food products from animal sources. Included in the research underway are projects on application of windmills to the cooling and storage of apples, the drying of food materials and grains by application of solar energy, energy balance determinations in canning plants, the conversion of solid waste from grapes and apples to directly utilizable heat energy, determination of the energy requirements for each unit operation in citrus plants, and the use of the ultra-high-temperature sterilization process for milk.

Program Needs

The 1976 research projects from the State agricultural experiment stations reflect only the very early response to the "Energy Crisis". If information and data were available on projects begun since 1976, it would surely show increasing emphasis on energy-related work. As a matter of fact, from the review of proposed project work it is known that in the PHT area there is work underway on the use of solar energy, waste heat recovery from unit operations, equipment modifications for energy conservation, determinations of energy requirements and balances for all operational steps from time of harvest until consumer purchase and the use of new processes to reduce refrigerated storage of products. An intensification and expansion of this area of work in needed.

References

Hirst, Eric. Food related energy requirements. Science 184: 134-138. 1974.

Energy Use in the Food System. Federal Energy Administration, May 1976.

A National Program of Agricultural Energy Research and Development. A Report to the National Planning Committee of the Agricultural Policy Advisory Committee. September 1976.

Joint Study of the National Association of State Universities and Land Grant Colleges and U.S. Department of Agriculture. September 1976.

Energy Analysis in Food Process Operations. A symposium at the IFT Food Engineering Division Annual Meeting, 1976.

Table 6. PHT Energy and Renewable Resources (Goal 1)

Funds and Manpower Assignment by Regions for FY 1976

Region	Source of Funds ($1,000)						Manpower
	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	Scientist Years
Northcentral	106.0	88.0	260.1	26.1	294.9	488.9	4.4
Northeast	10.2	-	20.9	.8	22.4	32.7	1.1
Southern	59.6	1.8	35.2	8.4	44.9	106.2	1.7
Western	26.6	1.3	54.0	25.0	79.0	106.8	1.5
Total	202.4	91.0	370.1	60.3	441.1	734.6	8.7

GOAL 2. ENVIRONMENT

Problem and Social Impact:

Environmental protection efforts are increasingly directed toward prevention of adverse health and ecological effects associated with specific compounds of natural or human origin which pollute our air, soil and water resources. Americans are reacting to the environmental problems they see around them and are insisting that we reclaim the purity of our environment and protect it from further degradation.

Industries involved in the assembling, processing, storage, transportation and distribution of foods impact upon the environment in many ways. The disposal of waste materials, both organic and inorganic, is a difficult problem but disposal must be achieved with adequate protection of the environment. The Federal Water Pollution Control Act Amendments of 1972 stipulate that "It is the National goal that the discharge of pollutants into the navigable waters be eliminated by 1985." In order to achieve this goal greater efforts and resources will have to be committed for research and development. Operations at food processing plants can cause atmospheric pollution due to release of volatile materials which cause offensive odors and the inclusion of particulate materials with the discharge of steam. Noises from the operation of equipment must not exceed the levels that will be harmful to employees or the public.

All the complex questions of locating future industrial plants, providing the products demanded by the public at reasonable costs and planning for economic growth are coming into focus. Environmental protection is essential to maintaining our quality of life. It will demand attention throughout the next decade. Public confidence must be maintained in the industry operations that are so essential for getting the raw materials from the agricultural production sector to the consumers.

Current Program

The environmental research projects contributing to PHT were identified by the key words "processing wastes" and "wastes". Table 7 shows that 14.0 SY's and $1,281,935 were contributed to the solution of PHT-related environmental problems in 1976. The Northeast region devoted a greater effort to this area of research than the other regions. The States expended almost four times as much funding on the support of the environmental research as came from Cooperative Research-administered funds.

Previous and current research has focused upon characterization of the nature and scope of the environmental problems. Since the majority of PHT environmental problems center around disposal and handling of agricultural processing wastes, much qualitative and quantitative information has been developed relative to specific crops or commodities and conditions of operations. Attention has been given to separation of solid wastes, to design and evaluation of control measures, to reduction of water usage and to water reuse, to by-product recovery, and to waste treatment technology. Enzymatic treatments and microbial conversion of wastes were studied.

Program Needs

A deteriorating environment and an aroused public dictate continuing research aimed at protecting and improving the environment. Additional research is needed to provide the technology that will allow safe water reuse and to clean up waste waters discharged to the environment. Feasible, economic recovery processes for waste reduction and by-product use must be developed, including markets for recovered materials. The concept of "total" use must be extended and the systems approach to control must be exploited. Waste-handling methods must be improved if we are to manage solid wastes effectively. Waste-treatment technology requires further study both with regard to devising biological processes for degrading and to overall safety. In-plant pollution control measures that reduce operating costs must be sought. Health and safety will be growing concerns. A satisfactory method of handling and disposing of packaging materials must be developed.

Air pollution must be controlled. Noise abatement measures need further development. Disposal of solid wastes on land raises challenging questions with regard to chemical residues and potentially harmful heavy metal contamination.

References

Federal Water Control Act of 1972.

Proceedings Seventh National Symposium on Food Processing Wastes - Environmental Protection Services EPA 600/2-76-304 December 1976.

Waste Management and Control, National Academy of Sciences - National Research Council. Publication No. 1400 Washington, D. C. 1966.

Agricultural Processing Wastes, Hoover, S. R. and L. B. Jasewicz, AAAS Publication No. 85 (1967)

Table 7. PHT Environment Research (Goal 2)

Funds and Manpower Assignment by Regions for FY 1976

Region	Source of Funds ($1,000)						Manpower
	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	Scientist Years
Northcentral	43.2	120.2	133.1	4.2	137.3	300.7	1.8
Northeast	92.3	69.8	254.7	31.1	338.8	500.9	6.5
Southern	52.4	1.1	138.5	.2	150.5	205.0	3.3
Western	6.1	44.4	199.9	12.2	224.9	275.4	2.4
Total	195.0	235.5	726.2	47.7	851.5	1,281.9	14.0

GOAL 3. PRODUCTIVITY

Problem and Social Impact:

In 1970, American consumers purchased $285 billion of food and fiber products and export markets took another $23 billion worth of products. Ideally the agricultural marketing system functions to move farm commodities to consumers in the desired form and condition at the lowest possible cost.

Constraints on the use of our natural resources require that the marketing system be modified in the direction of conservation and efficiency. In order to provide consumers with an adequate and nutritious supply of food in the future, much depends on our ability to develop the needed technological information to sustain improvements in productivity, the development of desirable innovations and to keep the marketing system operating at maximum efficiency. Attention to the component parts of the food marketing bill reveals the need for additional research in the PHT area. New and improved methods of processing, storage, and distributing food and other agricultural products must be investigated, including determination of both technical and economic feasibility.

Current Program

For a number of years a priority goal in the United States has been to seek improved productivity. The major effort in PHT research has been to improve the efficiency of processing and distributing food and fiber products and to develop products that would be demanded in new or expanded markets. In 1976 over one-half of the funding and manpower in PHT research was devoted to the goal of increased productivity. Table 8 shows that the resources assigned included $30.8 million and about 468 SY's. Technological advances or innovations have accounted for substantial reductions in costs of marketing. These have been and undoubtedly will continue to be the major force of change in the marketing sector. Thus, the primary objectives sought in PHT productivity research are those related to: (1) increased industry and employment growth resulting from the development of new technology; (2) increased efficiency in the market system by improving the methods used in processing, marketing and distribution; (3) the maintenance and improvement of competition; (4) reduction of costs for post-harvest marketing and distribution; and, (5) improved efficiency for small farmers, processors and distributors.

Program Needs

There is a continuing need to improve productivity in the market system. Technological innovations for energy conservation, environmental improvement and safety can render current processes obsolete. Development of new and improved products and processes requires continuing effort. New and economical means are needed to convert our renewable agricultural resources, including by-products and residues, into useful materials. There is a continuing need to add to the fundamental knowledge about the marketing system and the products marketed. In the long term, new knowledge will be the basis for future advances.

Improvements in marketing system, including physical efficiency, performance, structure, operation and supply, demand and price functions, will require additional research. Improving productivity in the post-harvest technology area is closely interrelated with other socio-economic goals such as energy and resource conservation, protection of the environment, quality, safety and reduction of losses Properly researched and exploited, these discoveries should help to assure a sufficient supply of high quality, reasonably priced agricultural products to meet domestic needs and to capture a fair share of growth in export markets.

References

(1) Post-Harvest Technology Research Assessment - Report Coordinated by Federal Research, SEA, USDA. September 1978.

(2) The U.S. Food and Fiber System: Selected Aspects of Structure and Performance, Campbell, G. and Peter Emerson, ESCS No. 139, Feb. 1978.

(3) The Post-Harvest Technology Agricultural Marketing System - A Descriptive Analysis, ESCS Special Report. September 1978.

(4) New Products and Profits proceeding National Conference on Individual Research Oct. 1968.

(5) The Economic Outlook for Food, Farrell, R. R., 1978 Food and Agricultural Outlook Committee print 95th Congress, Dec. 19, 1977.

Table 8. PHT Productivity Research (Goal 3)

Funds and Manpower Assignment by Regions for FY 1976

Region	Source of Funds ($1,000)						Manpower
	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	Scientist Years
Northcentral	2,816.6	877.4	3,851.8	857.7	5,648.0	9,342.0	125.0
Northeast	1,449.3	383.9	1,742.9	178.3	2,120.3	3,953.4	67.4
Southern	4,265.7	375.3	6,001.2	402.3	6,673.4	11,314.5	175.1
Western	1,575.6	540.7	3,444.2	429.2	4,051.8	6,168.2	100.8
Total	10,107.3	2,177.2	15,040.2	1,867.6	18,493.5	30,778.0	468.3

GOAL 4. REDUCTION OF LOSSES

Problem and Social Impact:

Wasted food is a wasted resource. The production of food alone does not solve the food problem. Food must be preserved in an acceptable, edible, and nutritionally adequate condition throughout production, processing and distribution and until consumed by those who need it. Many of the foods required for proper nutrition, such as fruits, vegetables, meat, fish, poultry and dairy products, are perishable and may undergo heavy losses unless given proper protection. Increased quantities of grains are being stored both on the farm and in commercial storage. Grain quality, in many instances, is deteriorating and storages are becoming infested with insects. Millers are concerned about insects and insect particles in food grains. Foreign buyers complain about large numbers of insects and extraneous materials found in shipments of wheat and other seeds used as food.

Food and crop losses occur at every level from production to consumption and are estimated at 20 to 30 percent of the food and feed produced in the United States. Losses are incurred through reduction in quality or in quantity, and are mediated by biochemical, microbial, mechanical and physical changes as well as by insects and other pests. Losses occur throughout the system. There are a number of widely diverse cause and effect relationships which are commodity-specific. Losses occurring late in the marketing system include not only the cost of production but all the costs of production inputs plus the cost of harvesting, storage, packaging, handling and distribution incurred to the point of loss. The objective of this research is to reduce food and crop losses and improve efficiency in harvest storage, assembly, processing, transportation and distribution of foods and feeds.

If food losses could be reduced a number of significant benefits would be realized: (1) the energy required for the production and marketing of the lost food would not be wasted; (2) the supply of food would be increased and would reduce the present requirement, with additional costs, for excess production; and (3) environmental pollution would be reduced because of the reduced disposal of food that has spoiled or is otherwise unacceptable.

In the U.S., about one-fifth of all food produced for human consumption is lost annually. This amounts to an estimated 137 tons valued at $31 billion. This perishable food lost between farm and the consumer would feed millions of people. From a worldwide standpoint the problem is even more acute. There are tremendous opportunities for reducing post-harvest losses in developing countries where losses frequently range up to 50 percent or more.

Current Program

Research seeks to reduce post-harvest losses by developing and applying improved post-harvest technology. Table 9 reveals $1,379,399 and 18.0 SY's are devoted to the search for ways to reduce losses. Researchers seek to find out where the losses occur, the cause(s) of the losses, the magnitude of the losses, and how to eliminate or reduce them. Aspects under study include: physiological causes, microbiological contamination and growth, physical and mechanical losses, insects, rodents, birds, spoilage, disease and product damage. The development of integrated pest management systems for stored products are of major importance.

Program Needs

It has been estimated that the losses of food materials could be reduced by 30 to 50 percent through development of new technology and procedures. For the United States, the result would be a 10 to 15 percent increase in the food supply without bringing new land into production. On a worldwide basis, the FAO also estimates if one-half of the world's food losses were prevented, enough calories could be saved to sustain a half-billion people.

Through surveys, the identity, characteristics and quantity of the major losses in materials which occur in the pipeline should be determined and the significant area of quick payoff identified. Research aimed at developing methods for prevention and control of losses during raw material handling, pre-processing and storage, final processing, distribution and preparation for final use should be expanded. An understanding of the biological and other mechanisms of change is needed before ways for prevention and control can be successfully developed.

Special attention should be given to upgrading and more fully using wastes for food and other purposes. Numerous by-products or "wastes" may be upgraded to food or a higher use category. There is a critical need for methods that may be used to extract and concentrate very dilute solutions. Research efforts should be directed to the application of the "total utilization" concept with regard to use of materials.

Study of the mechanisms involved in food deterioration and the response of food materials to stress during post-harvest or post-mortem handling is needed. This work is needed to determine the technical feasibility and economic advantages of pre-processing and storage of food materials in bulk for periods up to 6 months as a means of interim holding between harvest and processing. Current processing lines are products

[illegible] energy, water and raw materials were less scarce [illegible] look at the total system will frequently pay off. [illegible] each step or operation should be examined with a view [illegible] improved technology.

[illegible] product or material are the more subtle [illegible] loss of quality and the concurrent loss in nutritional [illegible] measures should be taken to protect and keep the [illegible] with high quality until it reaches the consumer. [illegible] and proper handling of materials in transit are [illegible] preventing distribution losses. There are many problems [illegible] reduction of losses in storage since improper [illegible] storage conditions cause deterioration and loss of [illegible].

[illegible]

[illegible] An Opportunity to Improve Resources Use. Report to the Congress Comptroller General of the United States CED-77-118 [illegible] 1977.

[illegible] Proceedings of National Food Loss Conference. September 12-15, [illegible], Idaho. M. V. Zaehringer and John O. Early, University of Idaho.

[illegible] Food Availability to Consumers VIII Study Team 6, World Food and Nutrition Study - Supporting Papers NAS, 1977.

[illegible] Potential Increases in Food Supply through Research in Agriculture - Report NSF Grant W STP 78-22533 Cornell University, Ithaca, N.Y. 1975.

(5) The Kansas City Conference - Research to meet U.S. and World Food Needs, Vol. 1, ARPAC Working Conference July 1975.

(6) The WARC Report - World Food and Nutrition Study; Section V, NAS, Washington, D.C., 1975.

(7) Proceedings of Spring Meeting of Research and Development Association 27 (2); 153, 164, 165 (1975).

Table 9. PHT Reduction of Losses Research (Goal 4)

Funds and Manpower Assignment by Regions for FY 1976

Region	Source of Funds ($1,000)						Manpower
	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	Scientist Years
Northcentral	136.3	7.2	156.6	19.7	228.9	372.4	4.3
Northeast	138.8	.4	185.5	12.8	205.6	344.8	5.1
Southern	49.4	7.3	191.2	8.7	205.4	262.1	3.6
Western	76.5	3.9	294.1	22.3	319.8	400.2	5.1
Total	400.9	18.7	827.5	63.6	959.8	1,379.4	18.0

GOAL 5 HEALTH and SAFETY

Problem and Social Impact:

Actuarial statistics show there has been a steady increase of life expectancy. Until recent years, diseases were the common cause of death, often at an early age. Today most of the bacterial diseases are under control and we know that the classical deficiency diseases - such as pellegra, scurvy, protein deficiency, etc. - can be prevented relatively easily. With the near elimination of most diseases we have become concerned about other safety factors that were not even identified a few years ago.

The foodborne diseases (including botulism), the gastrointestinal infections such as Salmonella, and the toxins produced by molds are potential hazards associated with the food supply. Environmental contaminants such as toxic metals (mercury, lead, cadmium) and various industrial chemicals (e.g. polychlorinated biphenyls) can be definite hazards if they get into the food supply. A number of the commonly used foods contain natural toxins and require special preparation for safe use. The tolerance level for pesticide residues must be under constant surveillance for the use of products. The safety of a number of food ingredients is an area of continuing concern.

Safe working conditions must be maintained in the industrial plants handling food and fiber products. Protection must be provided against high levels of contamination of the atmosphere by airborne diseases and dust. Noises in the industrial plants must be kept at a safe level and equipment must be operated with maximum protection against injury of employees.

Current Program:

In 1976 over $10 million and 128 SYs were assigned for PHT research programs on health and safety (Table 10). Of the seven socio-economic goals, this was the goal with the third largest program. Every region in the United States was placing considerable emphasis on this goal in their PHT research program.

The following are some of the studies at several locations: pesticide residues in agricultural commodities; degradation of agricultural pesticide in biological systems; reducing pesticide residues in foods; the toxicology and hazards for man and animals of drugs and chemicals; toxicological assessment of naturally occurring alkaloids; fungal toxic metabolites in food; fate of nitrate and nitrite in processed meats; transmission of viruses through food and water; and the hazards of mercury in biological materials.

Table 10. PHT Health and Safety Research (Goal 5)

Funds and Manpower Assignment by Regions for FY 1976

Region	Source of Funds ($1,000)						Manpower
	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	Scientist Years
Northcentral	667.5	770.3	1,248.2	158.1	1,455.3	2,883.1	32.0
Northeast	696.0	125.5	685.3	40.3	753.8	1,575.2	24.6
Southern	1,088.5	70.5	1,232.0	120.3	1,436.5	2,595.6	33.6
Western	437.3	583.2	1,687.4	167.0	1,955.5	2,976.0	38.2
Total	2,889.3	1,549.5	4,853.0	485.7	5,591.1	10,029.9	128.4

Program Needs

The future safety of the food we eat, the clothing we wear and the environment in which we live will be dependent to a large extent upon a continuing and high quality PHT research program. The Communicable Disease Center is continually documenting cases of illness caused by foodborne organisms. Some of these illnesses are resulting from processing and handling practices that are not adequate for microbial control. Under consideration is the elimination of the use of nitrite for some cured and processed meat products. There is a great question as to whether botulism will be controlled in some processed meat products without the use of nitrite. With the emphasis on energy conservation, changes in the time/temperature relationships are taking place in the processing of products and refrigerated storage. The possibilities for cross contamination of food products by foodborne organisms, toxic substances and chemicals can become an increasingly serious problem as the handling of more materials and operations take place within relatively limited areas. Only recently have we begun to realize the extent mycotoxins are present in the environment and the toxins that can be present in foods. New viruses are being identified that can be transmitted through foods. These and many other problems remain to be solved as efforts continue to provide the safest possible food supply.

References

Nitrites, nitrates, and nitrosamines in food - a dilemma. Scientific status summary of the Institute of Food Technologists Expert Panel. Institute of Food Technologists. November, 1972.

Toxicants Occurring Naturally in Foods, 2nd Ed. National Academy of Sciences, Washington, D.C. 1973.

Review of the Literature for 1977 on Food Safety - Non-Microbiological Hazards and Food-Borne Microbial Illness. Annual Report for 1977, Food Research Institute, University of Wisconsin.

Food Safety: A Program of Research for the Southern Region. A Report of the Food Safety Task Force for the Southern Region Agricultural Experiment Stations and the USDA. 1975.

A National Program of Research for Food Safety. Prepared by a Joint Task Force of the USDA, State Universities and Land Grant Colleges. 1968.

GOAL 6. PRODUCT QUALITY

Problem and Social Impact:

There is no purpose in extolling the merits of any agricultural products unless they are acceptable to consumers. A food can have excellent nutrient content but unless it is consumed no human nutritional needs are met. Food quality is the most important consideration for the acceptance and utilization of any food.

The primary factors which define food quality are consumer appeal, safety and nutritional value. In addition to sensory properties, consumer appeal includes convenience and price.

Current Program:

In view of the fact product quality is the key to having foods accepted or rejected, it is understandable that this is the socio-economic goal receiving the second largest amount of research effort. In 1976 product quality research was supported in the amount of $13,925,800 and 178.4 SY's (Table 11). This amounted to 21 percent of the manpower and 24 percent of the funding assigned for the PHT research (Table 5). Seventy percent of the research was on activity for the identification, measurement and maintenance of quality. Much of this effort related to the maintenance of quality in the marketing of fruits, vegetables and animal products. The improvement of grades and standards for crops and animal products was another major input.

Program Needs

During this century there has been a steady increase in the preservation of foods through use of heat processing, refrigeration, freezing, dehydration and chemical preservations. This has brought about dramatic changes in the marketing of foods; particularly noticeable are the shifts since the 1950's. The convenience foods have taken over an increasing share of the market, relieving families of the long hours required for food preparation in the home. But with these changes are arising the numerous questions about dietary selection and health.

The need for a rather detailed and complete nutrient data bank for all types of foods is a high priority. Research is needed to develop improved methodology for the determination of nutrients, the availability of nutrients in food systems and the relationship of physical and chemical measurements with sensory responses. The identity of compounds that enter into the development of flavor, often undesirable flavors, needs to be known. Continued attention must be given to quality attributes and quality assurance.

Table 11. PHT Product Quality Research (Goal 6)

Funds and Manpower Assignment by Regions for FY 1976

Region	Source of Funds ($1,000)						Manpower
	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	Scientist Years
Northcentral	1,043.9	244.4	1,426.3	159.5	1,987.7	3,276.0	39.3
Northeast	945.4	60.8	1,064.2	208.5	1,390.5	2,396.8	32.6
Southern	1,662.9	137.2	2,570.1	105.3	2,892.2	4,692.2	65.0
Western	590.4	140.6	2,322.0	333.0	2,820.7	3,560.8	41.6
Total	4,251.6	583.0	7,382.6	806.2	9,091.1	13,925.8	178.4

Many foods are being fortified or modified with additions of vitamins, minerals, fiber, color and other components. The influence of these on the overall quality, acceptance and need for improving nutritional properties should be better understood.

References:

Food Quality: Effects of Production Practices and Processing. Publication No. 77 American Association for the Advancement of Science. Washington, D.C., 1965.

World Food and Nutrition Study Vol III. National Academy of Sciences, Washington, D.C., 1977.

GOAL 7. BALANCE OF PAYMENTS

Problem and Social Impact:

Today, U.S. agricultural production is so large and reliable that we are able to feed ourselves and a large portion of the rest of the world. However, more use could be made of agricultural product sales to help the balance of trade deficits. Agricultural exports have expanded greatly in recent years. Exports reached $23 billion in 1976, up more than fourfold since the early 1960's. In 1977, the United States exported about 54 percent of its wheat crop, about one half of the soybeans, about one-fourth of the corn, and some 40 percent of the cotton crop. Since agricultural exports exceeded imports by $10.6 billion in 1977, this surplus helped to offset the $20 billion trade deficit in the non-farm sector. It is estimated that each dollar of agricultural exports stimulates an additional 96 cents of output in the U.S. economy, or a multiplier effect of almost 2.

Obviously, agricultural exports make a substantial contribution to the economic health and stability of the United States. Maintenance of the commanding American position among world food exporters plays a key role in the U.S. balance of payments. Further expansion of the export market for food is desirable in order to develop more favorable U.S. balance of payments. Research in post-harvest technology plays a vital part in maintaining and enlarging the export market. A more intensified PHT research program directed to the product attributes sought in the foreign markets could probably reflect favorably on the export trade.

Current Program

Table 12 provides insight into the nature of PHT research most directly applicable to improvements in the balance of payments position. Slightly over $1 million and almost 16 SY's are devoted to research in this area. The major part of this research was carried on in the Northcentral and Western regions. The research has been directed to improved methods for the development of foreign markets. Technical assistance to developing countries is augmented by work designed to discover means for improving the economic and physical efficiency of foreign markets. Attention is given to devising ways to more nearly satisfy consumer demand and enhance consumer satisfaction. Techniques for marketing and distributing products are sought which will deliver higher quality and maintain quality for longer periods of time while products are in the channels of trade.

Program Needs:

Technological innovation is reported to have been responsible for 45 percent of the Nation's economic growth from 1929 to 1967. It remains the key to our ability to compete in world trade, since a $20 billion trade deficit is not so much the result of the oil bill as it is our inability to pay for it with exports.

Research is needed to assure that processing methods and distribution systems deliver to the foreign customer products that are safe, of high quality and meet the specifications or customs of the importer. For example, durum wheat or wheat products exported to Italy must meet the specifications desired for Italian pasta products. Exported plant protein food products must meet the requirements with regard to functionality and nutritive value. More work aimed at devising products and processes that insure acceptance of U.S. commodities and products by foreign consumers is necessary.

Innovations designed to increase the nutritive value and quality of exported food products must be developed. Rather than exporting raw agricultural commodities, developments in technology should be used to add value and create new markets.

Post-harvest technology research can help to insure that the U.S. will be a reliable world food supplier. It can help capture a larger share of the growing export markets by assuring high quality salable products and an increasingly efficient marketing and distribution systems. An improved balance of payments position requires: (1) expansion of exports, (2) export of higher value commodities, (3) reduced dependence on imports, and (4) available technology to maintain product quality and to meet and expand export demand.

Post-harvest technology research should result in expanded markets and additional dollar returns to farmers, processors and suppliers. The inherent quality of agricultural products marketed should be enhanced, be better protected in the channels of trade, and thus, be more acceptable to foreign consumers. The overall effect should be improved balance of payments for the U.S. in international trade.

References

The U.S. Food and Fiber System: Selected Aspects of Structure and Performance. Campbell, G. and Peter Emerson, ESCS Rept. No. 139, Feb. 1978

1978 Food and Agricultural Outlook Committee Print, Dec. 19, 1977, pp. 7-32.

The Post-Harvest Technology Agricultural Marketing System - A Descriptive Analysis, Post Harvest Technology Research Assessment - Vol II page 141, Sept. 1978.

Table 12. PHT Balance of Payments Research (Goal 7)

Funds and Manpower Assignment by Regions for FY 1976

Region	Source of Funds ($1,000)						Manpower
	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	Scientist Years
Northcentral	130.4	30.1	138.7	8.9	170.9	331.4	5.1
Northeast	34.1	–	69.4	–	82.5	116.7	1.7
Southern	119.3	43.7	92.5	.4	94.3	257.3	3.8
Western	100.2	8.5	190.0	2.2	205.1	313.8	5.1
Total	384.0	82.2	490.5	11.4	552.9	1,019.2	15.7

GOAL 8. SUPPORT OF REGULATORY AND ACTION AGENCIES

Problem and Social Impact:

There are a number of Federal, State and local government agencies responsible for carrying out regulatory aspects of the food industry as provided for under legislative actions. The consumers expect the products they purchase to be safe, wholesome, properly labeled and truthfully advertised.

Grades and standards are established for many food products. Grades and standards describe the characteristics of a product so that producers, processors, wholesalers, retailers and consumers can gage product utility and assess its value for intended use. Grades and standards facilitate buying and selling on the basis of product description without inspection. The usefulness of market information, important in the establishment of a fair price, is often dependent upon an adequate description and measurement for grades and standards. Grades and standards promote honesty and fair dealing in the interest of consumers.

Regulatory or action agencies rely on proper product specifications, standards or definitions in carrying out their functions. Minimum quality characteristics, esthetic factors, truthful labeling, wholesomeness and health and safety considerations may be involved. Frequently, regulatory agencies need help in establishing specifications, quality criteria or safety. Research can supply the extensive technical data needed to establish specifications, develop new methodology or assist in matters involving toxicity, safety and wholesomeness and in establishing definitions of quality and the methods for measuring quality.

Current Program

For the 1976 research program, 22.1 SYs and $1,737,383 dollars were directed to grades and standards research which was useful in regulatory applications, in marketing and in quality control (Table 13). The Southern and Western regions were devoting more efforts than the other regions that were contributing directly to the work of regulatory agencies.

Effort was devoted to determining the chemical, physical, microbiological and organoleptic properties of agricultural products and commodities. Regulatory agencies, such as the State department of agriculture laboratories, apply these findings in the testing, analyses, and analytical services performed in carrying out their functions.

Table 13. PHT Research in Support of Regulatory and Action Agencies (Goal 8) Funds and Manpower in Program by Regions for FY 1976

	Source of Funds ($1,000)						Manpower
Region	CR	Oth. Fed.	State	Industry Grants	Total Non-Fed.	Total Funds	Scientist Years
Northcentral	75.3	8.3	129.1	3.9	148.4	231.9	2.3
Northeast	34.7	4.8	68.1	2.5	72.9	112.4	1.4
Southern	328.2	8.8	476.1	35.9	590.1	927.2	12.7
Western	68.5	20.9	322.3	43.6	376.5	465.9	5.7
Total	506.7	42.8	995.6	85.9	1,187.9	1,737.4	22.1

Other research in this area is aimed at developing methods and improvements in methodology, including techniques for monitoring product quality. Basic knowledge regarding product attributes is developed as needed.

Researchers provided assistance with toxicological problems such as detection of potential toxicants, assessment of the toxicants as carcinogens and other safety considerations.

Program Needs:

Grades and standards need continuous review and updating to remain current with technological advances and to properly characterize new product introductions. By the same token, regulatory agencies need a constant infusion of the latest scientific developments if they are to properly serve society. As marketing and distribution systems expand and international trade becomes more extensive, the need for reliable grades and standards to facilitate trading increases.

Research work on methods for identifying and measuring quality characteristics must continue. Basic research on the quality attributes of fruits and vegetables, cereal grains, animal products, forest products and other field crops as well as on numerous consumer-ready products is needed. Objective methods are needed to replace subjective methods. Automated methods are needed to permit continuous quality control or monitoring efforts. More use could be made of physical and chemical properties if properly related to quality and consumer satisfaction.

Additional work on interrelationships is needed for development of quantifiable bases for grading, labeling, processing and pricing according to end use. Basic research is needed to provide a reservoir of knowledge on which continued development of technology rests. Applied research, that puts together basic knowledge and practical application, will always have a significant role.

References

World Food and Nutrition Study - The Potential Contributions of Research, The National Research Council, National Academy of Science, 1977.

The World Food Situation and Prospects to 1985, ERS, USDA Foreign Agricultural Economic Report No. 98, 1974.

Food Standards - Facts For Consumers, USDHEW Food and Drug Administration Publication, Revised 1964.

Regulation, R. J. Anderson, USDA Yearbook 1966, pp. 364.

GOAL 9. BASIC RESEARCH

Problem and Social Impact

There are many problems faced in post-harvest technology for which there is an inadequate base of fundamental information for seeking immediate answers. Therefore, it is necessary to have a basic research program as well as an applied or developmental research effort. In CRIS basic research is identified as "research with the primary goal of gaining knowledge or understanding of a subject."

Frequently a part of the effort on a research project is devoted to basic research. The basic research under the project is often that part of the research effort to obtain fundamental information to answer questions on the phenomena that are observed in the applied phases of the study. Other research projects are devoted entirely to a basic problem for the purpose of gaining new knowledge which will be useful in advancing post-harvest technology.

Current Program

For the 1976 research projects classified in the post-harvest technology area, 32 percent of the scientific manpower and 32 percent of the funding was assigned to basic research (Table 14). Table 15 shows the percentage of the basic research by activity classification. The largest percentage of the basic research was in the activity on chemical and physical properties of food products. Since a fundamental knowledge of the functional properties of foods and food ingredients in developing new post-harvest technology is so essential, it is understandable that basic research on chemical and physical properties is receiving the most attention.

Program Needs

In order for the food industries with inputs to the post-harvest technology segment of the food chain to make new achievements of benefit to society, they will need a steadily enlarging library of fundamental knowledge. Additional basic data are needed on the properties of food and food ingredients that relate to nutritive value, flavor, color, sweetness, texture, aroma, toxicity, and other physical and chemical properties. More basic knowledge is required with respect to microbial infestations and the development and control of the organisms within food supplies. Basic information is needed with respect to the storage, transportation and handling of foods in order to provide better protection against food quality deterioration and losses. Relatively soon additional data must be obtained relating to the conservation of energy in the operation of the many types of

processes involved with the food chain. Data must be obtained on the use of new energy sources (e.g. solar) and/or the combinations of energy sources for the processing, storage, handling and transportation of foods and food ingredients. Industries that have inputs through the post-harvest technology segments of the food chain have difficulties meeting required environmental standards. There is inadequate fundamental knowledge on the biological, chemical and physical factors involved in the application of technology to the maintenance of the environment (water, air, soil, etc.).

C. Analysis of PHT by Research Activities

The post-harvest technology research has been analyzed by 17 broadly defined research activities as well as by the seven socio-economic goals. The research activities and the funds and manpower assignment in 1976 are shown in Table 16.

The research activities are taken from the USDA Manual of Classification of Agricultural and Forestry Research. The PHT research program is well distributed within the 17 activities.

The four categories of research receiving the greatest effort in 1976 were identified with the following activities: (1) identification, measurement and maintenance of quality; (2) chemical and physical properties of food products; (3) developing new and improved food products and processes; and (4) improving economic and physical efficiency in marketing including analysis of market structure and functions.

By combining the eight activities identified with "protection" approximately 20 percent of the research effort is encompassed in this area. This includes programs that are identified with environment, product losses, and safety.

If the activities on economic analysis and market development are combined, this encompasses approximately 20 percent of the research. This indicates that in 1976 there was a strong and active program related to the broad field of the economics of marketing. The 20 percent marketing requirement applied to Hatch funds has encouraged development of strong programs in marketing technology and marketing economics.

Table 16. Post-Harvest Technology Research by Activities
Funds and Manpower Assignments, 19[illegible]

	Research Activity	Funding ($1000) CR	State	Total	SY's	Percent of Total Funding	Manpower
4500	Protection against insects, mites, snails, slugs and control agents	663.7	1,224.7	2,234.6	26.3	3.8	3.2
4600	Protection against diseases, parasites and nematodes and their control agents	243.0	436.9	775.0	11.5	1.3	1.4
4700	Protection against weeds and their control agents	87.2	201.5	330.2	3.8	.6	.5
4810	Protection against fire	96.1	51.0	150.1	4.0	.3	.5
4830	Protection against pollutants	337.9	922.8	1619.3	22.8	2.7	2.7
4870	Protection against molds, fungi and other spoilage organisms	888.4	1661.2	3088.0	38.6	5.2	4.6
4880	Protection against allergens, toxins and poisonous plants	672.9	1009.0	2679.1	30.5	4.5	3.7
4890	Protection against radiation, noise and other hazards	89.4	299.5	521.0	6.2	.9	.7
5400	Chemical and physical properties of food products	2857.7	5044.8	9759.0	124.0	16.5	14.9
5500	Developing new and improved food products and processes	2038.7	4666.6	8153.6	110.9	13.8	13.3
5600	Chemical and physical properties of non-food products	1070.6	1787.4	3460.3	52.5	5.9	6.3
57[illegible]0	Developing new and improved non-food products and processes	730.9	2662.8	4337.9	74.1	7.3	8.9
5800	Identification measurement and maintenance of quality	3051.9	5118.9	9854.3	128.6	16.7	15.5
5900	Improving economic and physical efficiency in marketing including analysis of market structure and functions	3356.1	2356.5	6985.0	112.7	11.8	13.6
6000	Analysis of supply, demand and price, including interregional competition	1526.0	1434.9	3412.7	57.0	5.8	6.9
6100	Developing domestic markets, including consumer preference and behavior	340.[illegible]	344.2	812.0	13.0	1.4	1.6
6200	Foreign trade, market development and competition	379.5	467.3	967.7	15.1	1.6	1.8
Total		18,430.6	29,690.0	59,148.9	831.5	100	100

Survey of Research Directors

The Food and Agriculture Act of 1977 (Public Law 95-113, 95th Congress, September 29, 1977) designates the Department of Agriculture as the lead agency of the Federal Government for agricultural research in the food and agricultural sciences. "The term "food and agricultural sciences" means sciences relating to food and agriculture in its broadest sense--including the social, economic and political considerations of... B) the processing, distributing, marketing and utilization of food and agricultural products." The act further states that the Secretary of Agriculture, in carrying out the Secretary's responsibilities, shall..."(3) coordinate all agricultural research activity conducted or financed by the Department of Agriculture - and (4) take the initiative in establishing coordination of State-Federal cooperative agricultural research, extension, and teaching programs funded in whole or in part by the Department of Agriculture in each State, through the administrative heads of land-grant colleges and universities and the State directors of agricultural experiment stations and cooperative extension services, and other appropriate program administrators."

Under the Hatch Act, similar responsibilities were assigned to the Secretary of Agriculture. These were in turn delegated to the Cooperative State Research Service (predecessor agency of Cooperative Research in SEA). At present Cooperative Research is the unit within SEA charged with representing the Secretary in administering the Federal-grant funds appropriated by the Congress for support of agricultural research at the State agricultural experiment stations and other client institutions.

Traditionally, research at the State agricultural experiment stations, supported with Hatch funds and related State funds, is under the leadership and administration of the respective State station Directors. The Director is responsible to the head of his institution and to its governing body. The station Director is not a Federal employee.

In administering Federal-grant funds, Cooperative Research, representing the Secretary of Agriculture, deals with the station Director as chief executive officer of his station. The Director is responsible for the research supported; for initiating and guiding the station's research program; for selecting and maintaining a competent staff; for maintaining conditions, relationships, facilities and an environment favorable to productive research; and for rendering account and giving satisfactory proof of performance. Since the Directors play

such a key role in research management and program development, it was deemed desirable to obtain their views regarding the scope and importance of PHT research and their assessment of the appropriate role for industry and university research. A discussion of the results of this survey follows.

All Directors were contacted by letter for their assessment of Post-Harvest Technology Research. Forty-eight of the 56 Directors, or their designated representatives, responded to the request that was sent to them. Six questions were addressed to the Directors. Following is a statement of each question and a summary of the responses received.

I. At your Experiment Station, what is the scope of or the projects included under PHT research?

There is a range of from a low of one project at Nevada to 57 at California. Most of the states list an extensive program in PHT research. The projects cover a wide range of problem areas including processing, quality evaluations, safety, nutrient retention and improvements, energy conservation, pollution control, transportation, storage, economic studies, export markets, etc.

II. At your Experiment Station, to which of your goals does PHT research contribute?

At most of the Experiment Stations the programs were included in one or more of the following goals:

a. Improvement in the efficiency of the marketing system.
b. Protection of consumer health.
c. Improvement of the nutritional well-being of consumers.
d. Finding new and additional uses for commodities, including foreign markets.
e. Development of new and improved products and processes.
f. Improvement of food quality.
g. Improvements in food safety.
h. Development of energy conserving technology.
i. Improved methods for pollution abatement.
j. Development of methods for reducing post-harvest losses.
k. Providing adequate food supply at lowest cost possible.

III. In your state, who are the primary beneficiaries of PHT research?

The majority of the Directors identified the consumer as the main beneficiary. Also, the farmers, processors and other agri-business organizations were identified as primary beneficiaries.

Consumers are the major beneficiaries in terms of improved product quality, adequacy of food supply, increased safety, improved nutritive value of products and cost reductions achieved through more effective marketing and processing systems.

Processors and other agri-business firms are beneficiaries through reduction of losses in processing, better quality control and reduced costs through adoption of new or improved technology.

IV. What are cost/benefit relationships of PHT research?

Most of the Directors indicated it was not possible to provide a true or meaningful cost/benefit evaluation. However, most provided examples of important developments that have taken place as a result of PHT research. Below are presented five of these examples. Additional examples can be found in the appendix.

a. Improvement of the quality of cottage cheese

In the early 1960's cottage cheese quality was quite poor in the marketing channel in Tennessee. As a result sales were also quite low. A PHT research project involving intensive examination both microbiologically and organoleptically of samples collected from dairy plants in the market channel implicated several causes. Research on these causes resulted in several improved practices which were carried to individual plants by extension personnel. The application of these practices has resulted in a definite improvement in quality of cottage cheese sold in this State. This improvement was demonstrated by recent survey of cottage cheese quality in which all samples were of acceptable quality after 10 days storage compared with 5 percent unacceptable as fresh samples and 50 percent unacceptable after 10 days of storage in a similar survey taken before the research was started.

b. Extending the storage life of apples

Controlled atmosphere (CA) apple storages make it possible to keep many apple cultivars in good salable condition for 9 months following harvest rather than 6 months where only low temperature storage is provided, according to researchers at the Massachusetts agricultural experiment station. This method of storage was not commercially available in New England until 1952 when a Massachusetts grower was shown that use of this method of storage had great potential possibilities for improving the quality and length of marketability of the principal cultivars. CA storage capacity in Massachusetts has grown from 5,000 bushels in 1952 to about 900,000 bushels in 1977-78.

c. New products developed from turkey

In 1972 Utah's turkey industry was selling 85 percent of its production as whole birds and only 15 percent as further processed meat. Utah State University was asked to solve a number of technical problems associated with the production of turkey ham, turkey frankfurters and turkey bologna. As a result of this work farmer cooperative processing plants in Utah now use 40 percent of their production for further processed products with an estimated increase in income to Utah of $1,200,000. This has also resulted in the availability of low-fat ham, bologna and sausages that were previously unavailable to consumers. This project alone contributes benefits in excess of six times the annual cost of post-harvest technology research in Food Science at Utah State University.

d. Energy conservation by utilizing residues of wood

Wood residues can replace oil as a fuel in maple syrup evaporators, according to University of Vermont researchers. Sources, handling, and transportation were investigated in addition to combustion characteristics. Pelletizing woodchips or bark provided a drier, more easily handled product while decreasing bulk about 50 percent. Use of such fuels can decrease fuel costs significantly in maple syrup production. Other possible uses are in space heating and drying of agricultural products. Conversion costs to the use of these fuels can be minimal.

e. Wool baler handles and transports fleeces more efficiently

A baler has been developed for wool fleeces which will rapidly and efficiently compress the wool to a greater density than possible with wool sacks. This increases the poundage which can be hauled in trains, cars or trucks and reduces the resulting freight cost drastically. The industry likes these bales which can be handled more readily in wool warehouses by materials handling equipment. The prototype of this baler has been evaluated and accepted by wool growers and wool pools in several places in Montana.

V. If your Station dropped most or all of its PHT Research would industry or other private organizations meet the continuing needs for this type of research?

The responses were unanimous with the viewpoint that industry or other private organizations would not carry on the needed PHT research. Only the very practical or "trouble shooting" research would receive significant funding and this would be only for the very large industries or trade organizations. Industries with research support are committed to defensive research and that which will result in quick profits. They would undertake very little basic research. Knowledge gained would be closely guarded for competitive advantage.

The majority of the companies in the food and kindred products businesses are small with less than 20 employees. Such firms cannot support meaningful research programs.

If the support for PHT research were not continued through the State agricultural experiment stations, there would not be locations for the basic training of the future scientists needed by industry. Graduate students are active participants on many of the experiment station research projects.

VI. Do you feel it is desirable to have a continuing joint effort by the Federal government, universities and private industry to meet the needs for PHT research?

Again, the Directors' responses were unanimous that a joint effort is essential. The State experiment stations and the universities work on the more basic problems for the development of knowledge for the agriculture and food systems; the Federal Government has a national focus on the problems; and private industry will deal with the problems for defense of their operations and will develop only those innovations for which they can realize the benefits. A study of the food marketing in other developed countries will be convincing of the strengths and advantages of a diversified PHT research effort. The United States is clearly the leader in post-harvest technology. Many of the university scientific disciplines and research groups frequently meet with special advisory committees including representation from various government agencies and the food industries in their state. The universities have continuing contacts and working relationships with government and industry through educational conferences, contacts by extension specialists and other faculty members, and visits to the laboratories.

The administrators and the scientists at the State agricultural experiment stations have found it extremely valuable to maintain several communication routes for themselves with industry and government groups. Through this means many of the needs can be met without overlap or duplication of efforts.

SUMMARY

This report presents the findings of an Office of Management and Budget (OMB) requested study of the post-harvest technology (PHT) research, in the United States, supported with funds administered in whole or in part by Science and Education Administration-Cooperative Research (SEA/CR) of the U. S. Department of Agriculture. Post-harvest technology research is defined as those studies related to the assembly, processing, packaging, warehousing, storage, transportation and distribution of agricultural products which support the food and fiber marketing system.

A total of $59.1 million and 831.5 scientists years (SYs) were devoted to PHT research in FY 1976. The funds came from these sources: 31 percent from CR-administered funds; 8 percent from other Federal sources; 50 percent from State funds; 6 percent from industry grants; and 5 percent from other sources. The data for funds and manpower distribution are also presented by the geographical regions.

A Current Research Information System (CRIS) printout of the program supported by FY 1976 funds was used to describe the post-harvest technology universe for this study. Evaluations and analyses of programs were made on the basis of selected socio-economic goals and of program activities identified in the Manual of Classification of Agriculture and Forestry Research. Also identified were those portions of the PHT program classified as (1) basic research contributing to advances in knowledge and (2) those supportive to regulatory functions of state and Federal agencies.

There was a significant amount of support for programs contributing to each of the seven socio-economic goals selected by AR and OMB to evaluate PHT works (See page 20). As expected, the major activity and support was for the goals related to productivity and product quality. However, the amount of the activity and the assignment of funds and manpower for health and safety, energy conservation, environmental protection, reduction of losses, and more favorable balance of payments showed that during FY 1976 important research efforts were underway contributing to these more recently identified priority goals. The distribution of the research activity among the several goals reflects the responsiveness of the research system to emerging issues and the effective management for maintaining the relevance of research programs.

Of the funds and manpower for State PHT research, 32 percent were assigned for basic research, (Table 14). This proportion was considered to be within the range for a well balanced program.

Approximately $1.7 million and 22.1 SYs were contributing to the support of regulatory activities, primarily related to research on grades and standards of products. The need for continuous monitoring and upgrading of the knowledge of product characteristics increases as a result of technological advances that foster useful changes in the marketing and distribution system.

A survey of the Directors of the State agricultural experiment stations provided a viewpoint regarding the content, scope, support, clientele served and justification for the PHT research program. Consumers were identified as the primary beneficiaries of PHT research; producers, processors, other agri-businesses, and State and Federal Government agencies were identified as secondary beneficiaries. Directors were unanimous in the opinion that private industry would not finance and carry out the needed PHT research to serve societal needs. The Directors identified areas of research they considered the responsibility of the public-supported institutions. Other areas of research were identified that should be the joint responsibility of the State institutions, Federal government and industry through a coordinated effort. That research considered the sole responsibility of industry was also identified. Careful attention is being paid to appropriate roles and responsibilities, to avoiding unnecessary duplication, to coordination of the planning and management, and to maximizing the use of limited resources.

The vital role that post-harvest technology functions play in linking agricultural production (supply) with consumer demands (markets) cannot be overemphasized. Continued successful functioning of the food and fiber system depends upon a strong PHT research program.

Of the total funds and manpower supporting all areas of agricultural research, approximately 10.9 percent of the funds and 12.9 percent of the manpower are allocated for PHT research. This is woefully inadequate for the research that should be carried on to deal with PHT-related problems. This is particularly true when one considers that over 65 percent of the consumer's food dollar is required to pay for functions performed in the marketing sector and less than 35 percent to pay for those functions in the production sector. In view of total research resources, it is evident that the responsibility for conduct of essential PHT research must continue to be the joint responsibility of the public and private sectors.

APPENDIXES

Table 14. Percentage of Total PHT Research Funds and Manpower Designated for Basic Research, 1976

Region	Percent of Total	
	Funds	Manpower
Northcentral	37	38
Northeastern	32	32
Southern	27	23
Western	34	32
Average	32	32

Table 15. Percent of PHT Funds and Manpower for Research Activity Designated for Basic Research

	Research Activity	Funds	Manpower
4500	Protection against insects, mites, snails, slugs and control agents	43	42
4600	Protection against diseases, parasites and nematodes and their control agents	31	31
4700	Protection against weeds and their control agents	28	21
4810	Protection against fire	15	13
4830	Protection against pollutants	38	36
4870	Protection against molds, fungi and other spoilage organisms	34	33
4880	Protection against allergens, toxins and poisonous plants	54	52
4890	Protection against radiation, noise and other hazards	27	26
5400	Chemical and physical properties of food products	44	45
5500	Developing new and improved food products and processes	29	29
5600	Chemical and physical properties of non-food products	44	40
5700	Developing new and improved non-food products and processes	34	40
5800	Identification measurement and maintenance of quality	28	30
5900	Improving economic and physical efficiency in marketing including analysis of market structure and functions	17	17
6000	Analysis of supply, demand and price, including interregional competition	19	19
6100	Developing domestic markets, including consumer preference and behavior	11	12
6200	Foreign trade, market development and competition	19	17

APPENDIX A

Table 1 Food and Kindred Products Businesses 1/

Regions	Establishments: Total (Number)	Establishments: With 20 Employees or more (Number)	All Employees: Number (1000)	All Employees: Payroll ($million)	Value added by Manufacture ($million)	Cost of Materials ($million)	Value of Shipments ($million)
Northeast	7,030	2,877	357.4	3,017.2	8,251.3	13,861.7	22,071.4
Southern	7,303	3,417	414.8	2,878.4	8,112.2	18,943.1	26,938.8
North Central	8,743	3,821	522.6	4,716.4	12,789.1	33,516.5	46,181.7
Western	5,108	2,211	274.6	2,309.9	6.464.0	13,478.7	19,868.5
Total	28,184	12,326	1,569.4	12,921.9	35,616.6	79,800.0	115,060.4

1/ Code 20 1972 Census of Manufactures, U.S. Department of Commerce, 1975.

Table 2 Food and Kindred Products Businesses by Commodities 1/

Regions	Meat Products (Number)	Dairy Products (Number)	Fruits & Vegetables (Number)	Grain Mill Products (Number)	Bakery Products (Number)	Sugar & Confectionery (Number)	Fats & Oils (Number)	Beverages (Number)	Miscellaneous (Number)
Northeast	918	1,246	631	378	1,391	398	136	943	960
Southern	1,369	688	468	1,026	704	272	319	1,109	1,377
North Central	1,471	2,012	685	1,171	979	306	253	929	921
Western	679	644	773	505	559	273	153	643	895
Total	4,437	4,590	2,557	3,080	3,633	1,249	861	3,624	4,153

1/ Code 20 1972 Census of Manufactures, U.S. Department of Commerce, 1975.

Table 3. Wholesale Food Business - Groceries and Related Products 1/

Regions	Establishments (Number)	Sales ($million)	Payroll Entire Year ($million)
Northeast	14,187	43,455.5	1,743.0
Southern	9,858	22,121.4	1,088.1
North Central	9,034	28,549.4	1,239.6
Western	5,452	12,331.0	763.0
Total	28,531	106,457.3	4,833.7

1/ Code 514 1972 Census of Wholesale Trade, U. S. Department of Commerce

Table 4. Retail Food Stores 1/

Regions	Establishments (Number)	Paid Employees 2/ (Thousands)	Payroll Entire Year ($million)	Sales ($million)
Northeast	136,641	526.5	2,682.3	31,250.2
Southern	51,857	440.9	1,974.7	25,685.8
North Central	43,571	470.7	2,402.9	25,869.2
Western	35,283	284.4	1,760.3	17,913.7
Total	267,352	1,722.5	8,820.2	100,718.9

1/ Code 54 U.S. Department of Commerce News, Dec. 17, 1973

2/ For week including March 12, 1972

Table 5. Eating and Drinking Places 1/

Regions	Establishments (Number)	Paid Employees 2/ (Thousands)	Payroll Entire Year ($million)	Sales ($million)
Northeast	144,789	666.4	2,856.0	11,189.9
Southern	61,108	626.3	1,571.8	8,404.9
North Central	87,155	786.7	2,362.2	9,840.9
Western	66,472	555.1	1,945.0	7,432.0
Total	359,524	2,634.5	8,735.0	36,867.7

1/ Code 58, U. S. Department of Commerce, 1972 Census of Retail Trade, 1975

2/ For week including March 12, 1972

Table 6. Research Activities and Research Program Areas (RPA) from the Manual of Classification of Agricultural and Forestry Research used in the Classification of Each Socio-Economic Goal

Socio-Economic Goal	Research Activity																
	4500	4600	4700	4810	4830	4870	4880	4890	5400	5500	5600	5700	5800	5900	6000	6100	6200
Productivity									401 403 406 410	314 401 402 403 405 406 410 904	318 401 403 405 407 409 411 906	401 402 403 405 407 411 705 906		314 502 503 509 510 904 906	502 506 507 513 904 906	502 508 904 906	
Reduction of Losses	404 408 412	404 408 412				404 408 412											
Health and Safety	701	701	701	705 709	701 702	702	701 702 709	702 709			315 705						
Product Quality									318 402 404 405 408 409 412 904	708	404 408 904		402 403 404 405 406 407 408 409 410 411 412 501 502 503 512 904 906		603		
Balance of Payments									604	604				603		603	502 601 603 604 906

APPENDIX B

EXAMPLES OF BENEFITS REALIZED FROM PHT RESEARCH

The following are a few examples of benefits that have resulted from PHT research projects in several of the States.

I. Arizona

a. Impacts of relative price changes of feed and cattle on marketing of U.S. beef.

Beginning in May 1976, beef from calves and yearling steers fed varying concentrate levels was distributed to Tucson consumers through a local supermarket chain. Each package of steaks or roasts contained a questionnaire designed to gage consumer reactions to the beef produced by the various feeding regimes. Questionnaires were also placed in some regular stores as a control. Results indicated that 80 to 90 per cent of the customers found the beef produced by the various feeding regimes to be acceptable in terms of leanness, taste, tenderness and overall satisfaction.

Consumers have benefited from this project through changes in store policies and procedures initiated by responses to the questionnaire. For example, some cuts are trimmed closer than before the survey began in response to comments from respondents. Other changes are possible as later survey results are analyzed.

b. Technological and structural changes in the marketing of beef.

Data were collected over a ten-week period from four meat markets in the Tucson area with the following objectives in mind:

(1) Determine costs associated with shrinkage of meat in the retail store.

(2) Determine costs associated with deterioration of meat in the display case through spoilage, reduction in quality and costs of reprocessing.

Results indicated that changes in policy as regards stocking, pricing, deteriorated meat as well as improvement in the environment of the coolers, cutting rooms and display cases could result in cost savings through less shrinkage and deterioration.

II. Arkansas

a. Changing practices for cotton ginning.

For many years it has been recognized that the operation of cotton gins for about 90 days or less each year is a very inefficient use of ginning facilities. This is especially true for the new high-capacity gins which in some cases represent an investment of $1,000,000 or more per gin. In order to operate cotton gins at a higher percentage of capacity, seedcotton must be accumulated during the harvest season and held for ginning at a later date. To facilitate this, a method of pricing multiple bale-lots of seedcotton was developed by researchers at the Arkansas Agricultural Experiment Station. The ability to determine the market value of cotton before it is ginned permits producers to continue to sell this cotton at harvest for cash to pay production loans, etc. It facilitates the accumulation of cotton by ginners for ginning during the off-harvest season. According to USDA researchers, the potential savings in ginning cost from this method of operation amount to $5.00 or more per bale or $60,000,000 or more per year to domestic cotton growers.

b. Containers for vine-ripe tomatoes.

Before 1966, Arkansas vine-ripe tomatoes were manually packed in wire-bound containers such as the 1/2-bushel basket. Surveys of markets revealed produce buyer dissatisfaction due to fruit damage from the roughness of the containers. Also, the lack of size and grade uniformity was criticized. Based on research recommendations, the marketing associations with memberships of approximately 1,000 growers adopted an industry-standard corrugated-paper lug box as a shipping container. Initially, gains were estimated to be $0.80 per container on 65 percent of the crop (500,000 lugs) that was sold in the new-type containers in 1966. Mechanical sizing and conveying in the packing operations has improved size sorting and reduced labor requirements by 14 percent, or 101 hours per 1,000 lugs. This would translate into at least a savings of 15,214 man-hours in packing Arkansas' 1977 crop of approximately 1.5 million lugs.

c. Methods for reviving specific horticultural industries.

Labor shortage and cost threatened the large scale production of small fruit crops in the U.S. and eliminated much of this industry in our region. Research at the Arkansas Agricultural Experiment Station was responsible for development of new mechanized systems for production, harvesting, handling and utilization of blackberries and strawberries; and the development of new cultivars adapted to these systems. Present application of these systems promises a healthy revival of these industries.

d. Quality control of processed sweetpotatoes.

Research at the Arkansas Agricultural Experiment Station in the area of polysaccharide degradation led to development of new processes which assure quality control of processed sweetpotatoes. These processes also allowed the utilization of freshly harvested sweetpotatoes by the baby food industry, thus eliminating decay losses and energy waste during traditional curing and storage of this crop.

III. Auburn (Alabama)

a. High quality flour from southernpeas.

Southernpeas (Vigna unguiculata) are high in protein, high in minerals, low in fat, and relatively abundant in the essential amino acid lysine. Most staple grains are low in lysine which limits the human body's ability to utilize the protein in these grains. Research being conducted at the Auburn University Agricultural Experiment Station is aimed at developing new food products to take advantage of the nutrient potential in southernpeas. Such a flour would have minimal protein damage from thermal processing, would be similar in appearance to wheat flour and would have substantially all of the bean flavor removed. Numerous processing variables have been examined for their influence on the physical and organoleptic characteristics of the flour. A process utilizing flash evaporation of the volatile flavor components followed by spray drying shows good potential for producing high quality southernpea flour.

b. Development of least cost routings for the transportation of products to market.

The problem of transporting goods to market as efficiently and inexpensively as possible has been with man since he evolved from the subsistence type economy and became dependent upon others for food and fiber. The number of customers and the size of service areas covered by many assembly or distribution systems make it practically impossible for even the most experienced route manager to evaluate all routing alternatives. Computerized quantitative methods are available to aid in the development of efficient least cost routing networks. Experience with these procedures has been beneficial to firms who have chosen to evaluate their transportation systems. For example, an analysis of the delivery network for an Alabama wholesale milk distributor indicated that through the development of more efficient routes, total delivery costs could be reduced 16 per cent. Also, total time required to make delivery was lowered by 35 per cent. Such savings are significant and are important in considering ways to reduce or limit future food price increases.

IV. Colorado

a. Delay of post-harvest deterioration of carnations.

Several years ago the Colorado carnation industry was faced with virtual extinction because of fusarium organism infestation of the cut flower stems and petals. The organism caused the flower to deteriorate in a 3-4 day period after harvest, which limited the distribution and sale to local-regional markets. Colorado State University scientists, in cooperation with the Colorado Flower Growers Association, were able to develop techniques for growing and harvesting carnations in a near germ-free environment. Post-harvest deterioration is now delayed up to 14 days. Today, the Colorado carnation industry is a flourishing $25 million a year industry--and the number two carnation growing state. As an example of how development in one industry can carryover into others, it is noted that carnations constitute the largest value of air freight shipments from Denver's Stapleton International Airport.

b. Reduction in the losses for fresh market peaches.

The Colorado peach growing industry is located in the western part of the state. Most of the peaches are sold in "fresh" markets, and the growing region can be considered to be very remote from the major metropolitan centers where the bulk of the peaches are sold. Until the early 1970's as much as 20 percent of the harvest spoiled during transport and storage at distribution centers. Colorado State University developed a spray treatment technology and a method of containerization which reduced waste by over 50 percent--providing benefits to growers, shippers and consumers alike.

V. Florida

a. Improvements for the marketing of sweet corn.

Precooling of sweet corn after harvest and before shipping as a means of retaining sweetness (sugar content) during marketing aided considerably in the development of the 55,000 acre sweet corn industry which had a crop value of $44,000,000 in 1976-77. In cooperation with industry, methods were developed for hydrocooling sweet corn to obtain maximum retention of sweetness and other flavor constituents and avoidance of pericarp toughness. Methods were also devised for vacuum cooling sweet corn without denting due to drying of the kernel. The trimming of the ears was found to have no effect on quality but allowed more efficient marketing. Smaller containers could be used with less weight which would allow more containers to be shipped per trailer truck thus reducing energy needs and shipping costs.

b. Controlling bacterial breakdown of vegetables.

(1) Radish growers and packers were plagued with a breakdown of the radish when they switched to packaging their product in plastic bags. The problem was found to be caused by a bacterium which entered the radish during the washing procedure. Changing the wash water more frequently and adding hypochlorite to the water eliminated the problem. (2) Hypochlorite solutions from chlorine gas or hypochlorite salts (laundry bleach or swimming pool disinfectants) were found to eliminate contamination of tomatoes and bell peppers by soft-rotting bacteria during the dumping and washing phase of packing those vegetables. Most packinghouses now chlorinate their dump-tank water and wash-water. As a result, much lower losses to bacterial soft rot have occurred recently even though the currently preferred tomato cultivar is much more susceptible to the disease than were the older cultivars.

c. Research applications that have resulted in citrus as a major industry.

(1) Prior to 1950, the methods for utilizing citrus fruits were not sufficient to cope with the expanding production of fruit. The development of concentrated frozen orange and grapefruit juice and specific analytical techniques for production and maintenance of high quality products enabled the citrus industry to expand to double its value to the state's economy in just a few years. The cost of the research at that time was very little in comparison to the annual benefit to the state for almost 30 years.

(2) Along with the development of frozen concentrated juices, research was done on utilization of the non-juice portions of citrus fruit, which amounts to 45 percent of the entire fruit currently amounting to approximately 5,000,000 tons. As a benefit of this research, there has been developed a large and stable by-products industry utilizing virtually 100 percent of the waste materials from the juice extraction process. This also has been extremely valuable to the state in increasing the value of the crop, improving the economy and virtually resolving a potentially large waste and pollution problem.

(3) For many years, the production of lemons in Florida was limited to dooryards and very small scale fresh fruit operations for local markets and some gift box trade. Through research, methods were developed to handle Florida-grown lemons so that now there is a multimillion box production of lemons, worth many millions of ›llars to the economy of Florida.

(4) During the past 30 years research at the AREC, Lake Alfred, Florida has enabled the Florida Citrus Industry to salvage more than $6,500,000 of citrus essential oils that had been contaminated with Fe, cu, Pb, etc. As a result of improved processing and handling technology, Florida citrus oils are recognized worldwide as having superior quality and flavor.

(5) With the advent of pulp wash concentrate for the beverage industry, the Florida citrus processing industry was faced with a dilemma as how to best produce a high density concentrate due to an aggravating viscosity problem which limited concentration to no more than 25 to 40 degrees Brix. Enzyme research at AREC-LA demonstrated that pectic enzymes could be used to reduce viscosity with no detrimental effect on concentrate quality and today 60 to 65 percent Brix pulp wash concentrates are produced routinely. This process has led to energy savings, lower shipping costs, reduced warehousing requirements and other improvements in efficiency as well as reduced costs.

(6) Research at AREC-LA has demonstrated that citrus juice sacs are a major contributor to air pollutants from citrus feed mill stack t gases. The segregation and recovery of juice sac which may be dried and utilized in human foods has resulted in substantial economic returns to the citrus processing industry with accompanying reduced air pollution.

d. Establishing adequate processing for microbial safety of precooked beef roasts.

As a result of recent salmonellosis outbreaks associated with pre-cooked beef roasts, a major producer of these products in the state contacted us and requested that we make recommendations regarding his processing operation. Evaluation was made across-the-board, i.e., from the manner in which raw quarters of beef were moved through the plant to the cooking protocol that was used in-plant. Sanitation adequacy was also determined. As a result of this work, numerous steps were taken to assume adequacy of processing in terms of microbial safety. USDA (FSQS) interim guidelines for cooking adequacy were implemented at about the same time. Meat industry groups contacted a private consulting laboratory to determine alternative processing regimes which are now in use. All groups, industry, university and private organizations, cooperated well. Recent work in our laboratories has indicated additional means for controlling product losses due to shrinkage while maintaining product quality and safety.

I. Georgia

a. High quality pecan products.

The development of the pecan industry from a seasonal crop characterized by low-quality and low returns to one delivering uniform, high quality products the year-round, has been due to several key applications of post-harvest technology.

First, the large losses from mold contamination were shown to be avoidable through rigid moisture control to a level not exceeding 4.5 percent.

Secondly, by storage at appropriate temperatures of 0 degrees C (32 degrees F), -4.25 degrees C (20 degrees C), -20 degrees C (0 degrees F), flavor and color could be controlled at the optimum level for consumption throughout the year.

Thirdly, the demonstration that the optimum quality of a nut is achieved before falling has enabled shaking and mechanical harvesting to be utilized. These applications have resulted in a healthy and growing pecan industry.

b. Improvements in the peanut industry.

Plant breeders and agronomists have developed several new disease-resistant or high-yielding varieties of peanuts in recent years. These peanut lines appeared to offer benefits of increased yields and profits to farmers as well as reduced costs for processed products to consumers. Food technologists at the University of Georgia conducted extensive processing and quality evaluation studies of new peanut varieties and found that many which appeared to be promising in terms of increased production possessed undesirable processing characteristics and were unsuitable for use in the commercial trade. Plant breeders and agronomists now work cooperatively with food technologists to include a program of quality evaluation of new peanut varieties to achieve optimum production, processing and quality characteristics. The importance of post-harvest technology can be readily appreciated.

VII. Idaho

a. Potato storage studies and economic impact.

The cost of and benefits from the development and implementation of the new potato storage technology were estimated. The compounded cost incurred in the development of this technology during the 1958-1973 period was estimated at $266,349. The present value of future benefits over the 27-year period (1974-2000) anticipated

life of this technology was estimated at $3.4 billion. Social rate of return to public investment in the development of the new potato storage method was estimated at 1323 percent.

The implementation of the new storage method has directly or indirectly contributed to 543 person/year increase in employment in the processing sector of the Idaho potato industry. This increase in employment has contributed $3.3 million annual increase in wages. The total annual economic impact of this increased employment on the Idaho economy was estimated at $5.2 million based on .75 marginal propensity to consume and 2.11 multiplier coefficient.

VIII. Illinois

a. Controlled atmosphere storage of vegetables.

A significant contribution concerning the use of controlled atmosphere for the storage and preservation of many fresh, refrigerated vegetables such as spinach, beans, broccoli and lettuce was made by researchers in the Food Science Department. Their results established optimal conditions for storage and showed quantitatively the advantages of controlled atmosphere storage during the shipment of these materials. These efforts, in part, resulted in industry adaption of this technique and its common use for shipment of these materials. Additionally, the research efforts aided in the development of suitable equipment systems for industrial use, for example, the Whirlpool Corporations' Techtrol Systems.

b. Development of processed foods from whole soybeans.

The Department of Food Science has developed a number of foods from whole soybeans. It has been apparent that there is a worldwide need for additional protein for human consumption, and soybeans have protein content of excellent nutritional quality. A controlled heat treatment for soybeans was developed before damage to the whole bean occurred during processing to eliminate objectionable flavor development. A series of prototype foods including such items as weaning food, canned bean and meat mixtures, breads and a number of dairy-like analogs have been developed. This has resulted in a considerable interest in this particular process and several companies (both domestic and foreign) are investigating their marketability. This particular post-harvest technology research has strong implications in the international arena and is being further developed through the auspices of several international programs. The adoption of this technology will result in energy savings and considerable economic advantages for equivalent nutrition when compared to alternate protein sources. Its impact on the economics of soybean production would be apparent following wide-scale use of this food product line.

IX. Maine

a. Establishing quality and shelf life standards for blue mussel shell stock.

Prior to research in our laboratory, the shelf life of blue mussel shell stock was not defined; neither were recommended procedures for handling mussels available. Research performed here has provided information with regard to the best handling procedures for blue mussel harvesters, resulting in a high quality product. Recommended storage conditions have resulted in a product of known quality with a relatively defined shelf life.

X. Maryland

a. Sterile fluid milk

The concept of sterile milk is not new, but it has not been accepted by the American consumer because of a "cooked" flavor. Station scientists working with a thin film sterilization technique developed by DASI Industries have produced a sterile fluid milk product that is as acceptable as normal pasteurized milk. The introduction and utilization of this product has the potential for significant energy savings and improved quality, and should result in lower costs to consumers. The first year of a 3 year study sponsored by the Department of Energy to develop a pilot plant and to conduct market studies is currently underway.

b. Extending the shelf life of fruits and vegetables by fumigating with acetaldehyde.

The estimated annual losses during transit and unloading of fresh fruits and vegetables in the United States exceed $200 million. The principal losses are caused by 10 major post-harvest pathogens. Station scientists have demonstrated that acetaldehyde at given concentrations acts as a volatile fungicide without adversely affecting the qualities of the fresh product. Acetaldehyde is a naturally occurring metabolite of respiration and has been cleared for use by both FDA and EPA. The use of acetaldehyde fumigation can more than double the shelf lives of fresh fruits and vegetables.

XI. Michigan

a. Prevention of bloating of pickling cucumbers during brining.

Two years ago 80 percent of the pickling cucumbers processed became bloated during the brining process. This limited their use to low value products such as relish. Michigan State University research developed a means of purging the pickle brine with nitrogen gas

which essentially eliminated the bloaters. This process has been universally adopted by the industry.

b. Computerized program for lumber yields and costs.

A computerized program to maximize hardwood lumber yields and minimize hardwood lumber costs in furniture manufacture has been developed. Savings of 5 to 20 percent have been reported by furniture companies using the program. Full adoption could mean an annual savings of $2 million for Michigan furniture manufacturers.

IIX. Minnesota

a. PHT and reduced food costs.

The benefits of PHT research far exceed the costs. Food costs are reduced through longer storage time, reduced wastage, higher quality foods, and new energy conserving processes. Freedom from fears of food-borne diseases is a benefit that all enjoy but cannot measure.

For example, (1) C. perfringens is one of the most common sources of food poisoning. Slow cookery of meat as in a crock pot or low temperature oven provides opportunity for food poisoning to develop. Minnesota scientists are developing guidelines for cooking meat to the desired state of doneness and preventing the risk of food poisoning in restaurants and homes.

(2) A new packaging technique developed at the University of Minnesota prolongs the shelf life of poultry and reduces the cost of transportation. Previously, the wet-ice method required 10-20 pounds of ice be used to cool 22-25 broilers placed in cartons. With the new carbon dioxide filled air tight, special nylon-surlyn film wrap, 15 to 25 percent more poultry can be shipped in smaller cartons at considerable savings and to much more remote markets.

(3) Minnesota scientists developed a small-farm scale process of making a high-quality Gouda cheese that permits small farmers without capital for land purchase to find full-time employment for themselves, members of their families, and neighbors on their farm.

XIII. Mississippi

a. Cured beef product made from animals fed on grain-free diets.

The American diet has not contained cured beef items for the breakfast meal. Research in product development at Mississippi State University has resulted in the development of a lean, flaked, and formed cured beef product from animals fed on grain-free diets.

This product is currently being put into commercial production and is a beef product that can be used as a substitute for boneless, defatted ham products that are so popular in the United States.

b. Fortification of milk with milk solids not fat.

Research dealing with fortifying milk with milk solids not fat was conducted at MSU. Work indicated fluid milk fortified with added solids more acceptable than same product not fortified. It is now common practice to fortify such products as skim and low fat milk with milk solids not fat. Since legalization of practice, results of this study have been of major economic importance to dairy industry. Millions of pounds non fat dry milk have been utilized in the fortification of fluid products. Consumers have benefitted from added nutritional value of protein, vitamins, minerals and other nutrients contained in added solids. Producers have also benefitted from increased utilization of total milk products.

XIV. Nebraska

a. Prediction of meat tenderness based on ratios of mineral constituents.

Prediction of tenderness of meat cuts is subjective and inaccurate. Research has determined that ratios of certain mineral constituents is highly correlated with meat tenderness. This finding has permitted the adaptation of a portable x-ray analyzer to measure predicted tenderness of meats. The concept has been patented, and licensure agreements for its use in meat grading programs are being developed. Great savings in grading costs and improved reliability of grade information are foreseen as benefits of this development.

XV. Rutgers (New Jersey)

a. Optimization of lime treatment of corn for preparation of tortillas.

Research has been conducted on the optimization of the lime treatment of corn for the large-scale preparation of tortillas. By physical methods we can predict the necessary treatment time to optimally dehull corn of any variety. This results in improved product quality; better retention of nutrient values, and an increase in manufacturing efficiency and therefore, conservation of energy. This research has national and international application. This basic research correlating the physical chemistry of food systems and mathematical relationships is considered a significant advance in the technology of corn masa preparation which dates from the Mayans.

b. Reduction of Rhizopus rot fruits and vegetables

Rhizopus rot was the most destructive disease of Eastern peaches on the market. Attempts to control this rot was unsuccessful until a NJAES plant pathologist found that this rot was easily controlled by the post-harvest application of 2,6-dichloro-4-nitroaniline. This discovery led to the commercial use of this material on a number of fresh fruits and vegetables, effecting a dramatic reduction of losses from this rot.

c. Modification of storage procedures to control disease in the Centennial sweetpotato variety.

A disorder of the leading sweetpotato variety, Centennial, began to appear several years ago after the potatoes were cooked. Because the sweetpotato with this disease had no external symptoms, the losses from this disorder were borne completely by the consumer and/or the retailer. In one year alone, losses due to this disorder were estimated to be 1,000,000 pounds in the New York Metropolitan area. Plant pathologists participating in a specific Cooperative Agreement between the NJAES and ARS discovered the cause of the disorder and developed a simple, specific storage regime which eliminated it. Not only did these studies "salvage" the Centennial variety but were responsible for the introduction of the hard core resistant, Jewel variety.

XVI. New York

a. Controlled atmosphere storage of apples (Cornell).

The development of controlled atmosphere storage of apples at Cornell cost about 13 scientist years and $780,000. This resulted in annual return to the industry of about $2,250,00 and brought apples to the consumer year around.

b. Increasing pack per ton and reduction in waste disposal in sauerkraut processing (Geneva).

New York is a leader in the production of cabbage and a big market for this cabbage is in the form of sauerkraut. Case pack per ton of raw product is a big concern of the processor as well as the waste (brine) he must dispose of. A new variety, "Hi-Dri", was developed for the New York area which improved the pack yield by up to 45 percent. At the same time the amount of brine was reduced that had to be taken care of in their waste disposal system. Further treatment of the sauerkraut waste was researched and developed in another project.

XVII. North Carolina

a. Country-style ham developed into a major industry.

In country-style ham studies, the interrelationships of curing times, equalization of curing ingredients within hams, aging time, and control of relative humidity, temperature and air flow were determined. This work resulted in controlled moisture losses, more rapid flavor development, elimination of mold growth and more complete standardization of ham quality. The country-style ham industry developed rapidly in North Carolina after it placed into practice the results of this research. The gross income of the industry grew from about $10 million per year to about $100 million in about 10 to 12 years.

b. Sweet acidophilus milk.

Five to ten years of basic research culminated in the development of SWEET ACIDOPHILUS MILK. Since its introduction in April 1975, the product has now reached production in approximately 38 States. Representatives in the dairy industry have spoken of it as the first major development in the fluid milk industry since the introduction of vitamin D milk. The milk is being accepted quite favorably by consumers, many of whom advise us that various problems associated with their digestive systems have been alleviated since this product has been available. Such types of testimonials tend to confirm various research reports in the literature that have described various beneficial attributes resulting from the ingestion of Lactobacillus acidophilus which had heretofore been available in milk only as ACIDOPHILUS MILK - a very distasteful product which has not been on the market in any quantity since World War II. Additional research is being conducted at our university and in collaboration with different medical schools to identify additional beneficial characteristics of SWEET ACIDOPHILUS MILK. An increasing volume of studies dealing with intestinal microorganisms indicate that the lactobacilli contribute beneficially to different intestinal functions.

XVIII. North Dakota

a. Improvement of malting barley in order to retain an industry.

The barley production industry of North Dakota is here only because of a concerted effort by the public institutions and the MBIA (Malting Barley Improvement Association) in the early and mid-1950's to keep the acreage of malting barley, which was in Wisconsin, from moving from western Minnesota and eastern North Dakota to Montana and west. The MBIA initiated a grant which was to encourage additional malting barley improvement by the publicly supported plant breeders and cereal chemists. This effort has paid

off handsomely since in 1977 we produced 98,670,000 bushels of barley worth $157,872,000. This represents 24 percent of the barley in the United States and places North Dakota in first place. The continued strength of the barley industry due to high quality and high-yielding varieties is evident in the establishment of two malting barley processing plants in or near North Dakota.

XIX. Pennsylvania

a. Increased canned yields of mushrooms by pre-treatments of raw product.

Low and variable yields of canned mushrooms present a problem to Pennsylvania processors in their efforts to meet the economic impact created by imports of canned mushrooms from countries with lower labor and overhead cost. As a result of research conducted by personnel of the Department of Food Science, a number of processing options which could increase canning yields significantly had been offered. Increased temperature, post-harvest storage, combined with soak treatments of the raw product have been shown to increase can yields by 15 percent or more. Increases of smaller magnitude are possible by applying storage with soak treatments independently. Savings resulting from each 1 percent increase in canned product yield have been estimated as $10,000 per million canned pounds. About 60 million pounds of mushrooms are canned annually in the Commonwealth. Elements of these processing options are currently being adopted by processors in Pennsylvania and also abroad.

b. Improvements in the safety and prevention of spoilage of products home canned.

Beginning in 1974, an unexpected interest in home canning quickly depleted the normal supply of jar lids made by traditional manufacturers. Seal failures of lids made and marketed in 1975 by an inexperienced manufacturer sparked a multitude of requests from home canners for assistance. Therefore, an evaluation project was promptly conducted to ascertain the effectiveness of jar lids available to home canners, the results of which were published as an Agricultural Experiment Station progress report. Only five of nine jar lid brands tested were found to perform satisfactorily. All four jar lids found to be unacceptable were removed from the market and in one case redesigned to higher quality standards. Over thirteen thousand copies of the report were circulated by two jar lid manufacturers and 11 state extension services. Mass media coverage was nationwide including discussion of the study on NBC's "Today Show". This research was continued on an expanded scale in 1976-77 to further improve the seal performance of jar lids used in home canning.

XX. Puerto Rico

a. Processed products from plantain.

Several years ago plantains were mainly used as fresh produce by the consumers. The Food Technology Laboratory undertook the development of technology for the complete utilization of the commodity. Successful processes were developed for the production of plantain chips, frozen green plantain, frozen tostones, green plantain flour and a dessert of ripe plantain in syrup. These processes have led to the development of an industry devoted entirely to the utilization of the plantain. As a result of the increment in the outlets provided for the utilization of the plantains, the farm value of the crop increased from $1 million to almost $23 million a year.

b. Cost reductions for milk delivery.

Distribution costs are the most important single expense involved in moving milk from the farm to the consumer. At the beginning of the 1960 decade the need was realized for research to determine the costs of milk distribution and to evaluate whether possible changes in the distribution system would be desirable. Retail milk distribution was done daily from Monday through Saturday with no deliveries on Sundays. A time study was undertaken to determine and measure the effect of different time factors upon retail route costs and efficiency. It showed that every-other-day deliveries might reduce the cost of distribution. The adoption of an alternate-day delivery system brought costs savings between 0.5 and 0.7 cent per quart of milk in home deliveries, which by that time comprised over 94 percent of the total volume distributed.

XXI. Clemson (South Carolina)

a. Improving the nutritional status of textile workers.

South Carolina has a large textile industry that provides lunch breaks for its employees. In order to improve the nutritional status of its work force, studies were undertaken to determine ways to provide a more nutritious beverage for vending during lunch breaks. This was done by using coffee flavored milks and frozen milk shakes. Because coffee is a preferred beverage, the use of this flavor in milk increased the consumption of milk. Because milk shakes are a highly nutritious beverage, efforts were made to provide a milk shake that could be vended. A milk shake was formulated, frozen and successfully dispensed through a vending machine. The industrial worker thawed the shake in a microwave oven and then had a pleasing nutritious beverage.

b. Consumer preference for fortified low-fat milk.

Extensive consumer preference studies to determine the acceptable composition of milk were made. Milks modified by adjusting the ratio of fat to solids-not-fat were made and subjected to taste panels of adults and children. The results of these studies indicated a desire by the consumer for a fortified low-fat milk. Since these studies, fortified low-fat milks are sold in the market place and their sales have increased due to the desires of the consumer.

XII. Tennessee

a. Ensiling vegetable wastes from vegetable processing plants to meet environmental quality standards.

Vegetable canners have encountered serious problems with the disposal of solid waste in their efforts to meet the new environmental quality standards. Research to characterize this waste was initiated in cooperation with two large processors in Tennessee. Characterization allowed the quick development of a system to ensile this waste and produce an edible silage for use for feeding beef cattle. One large plant is using this system with considerable economic advantage over other methods. This practice has considerable potential for other vegetable processing plants.

XIII. Texas

a. Imitation cheeses made with vegetable proteins.

Imitation cheeses of good organoleptic quality and low cost have been developed using vegetable proteins to replace up to 50 percent of casein. Flours and isolates and concentrates of peanut and glandless cottonseed have shown promise in this application.

XIV. Utah

a. A low cost starter medium from whey for use in cheese manufacture.

Because of rapidly increasing prices, the cost of commercial starter media has become a major manufacturing cost for cheese factories. In 1975 Utah State University developed a low cost bulk starter medium that can be made in cheese factories from their own whey. This medium with its pH control system results in starter that is 2-3 times more active than conventional starter. The system has now been installed in four cheese factories, all of which are farmer cooperatives. The largest processes about 600,000

pounds of milk daily into Cheddar cheese. They have reported that the new starter system saves them about $190,000 per year. One of the other plants reports savings of $110,000 per year. Additional cheese factories will soon be on the program. This single development is now providing benefits in excess of the total annual costs for post-harvest technology research in Food Science at Utah State University.

XXV. Vermont

a. Use of major locally produced raw materials for a new flavored yogurt.

Two important Vermont agricultural products - milk and maple syrup - have been combined by University of Vermont scientists into a maple-flavored yogurt that is now on the market. After trained taste-testers judged a large number of samples, a formulation was recommended for industrial manufacture that contains 14 percent commercial grade maple syrup. It is a Swiss-style, natural yogurt; no artificial colors, flavors, stabilizers, sweeteners, or preservatives are used. The maple-flavored yogurt has a shelf-life of about 1 month when kept refrigerated.

XXVI. Virginia Polytechnic Institute

a. New grade standards for apples.

Research conducted at VPI & SU resulted in new grade standards for apples based on apple size, percent peel trim, percent defect trim, and percent soluble solids. These grade standards reduce the risk in yield and plant time requirements, give processors a basis for planning their utilization of receipts and plant line setups, and give producers an incentive to deliver apples of greatest value to the processor. With the new grades and programmed scheduling of apples through a plant, the pounds of apples dumped daily can be increased nearly 27 percent and applesauce production increased 31 percent. Also, the percent of utilized cooker capacity increased about 22 percent.

The adoption of the new grade standards and use of the inspection in planning processing would result in a 25 percent reduction in processing costs. This would amount to approximately $2,000,000 which would be saved and could be either passed on to consumers, passed back to producers, or kept by the processors - depending on elasticity of demand of consumers, elasticity of supply of producers, and competition among processors.

b. Mechanical harvesting of tomatoes.

Research at VPI & SU concerned with the effects of mechanical harvesting of tomatoes in Virginia on cost of harvesting and quality of processed product indicates that labor was saved and quality of the product for processing was improved. In Virginia the labor saving aspect of mechanical harvesting did not lead to a displacement of hand pickers because at the going wages a supply of hand pickers was not available. In 1974 the reduction in labor required to harvest tomatoes was approximately 40,000 man-days per season which resulted in about a 1/2 million dollar harvest cost saving to tomato producers in Virginia. About 75 percent of these harvest cost savings occurred to tomato producers on the Eastern Shore.

In addition, the mechanical harvesting variety of tomatoes harvested mechanically produced a higher conversion ratio of raw tomatoes to processed products. In 1974 the net value of this improved conversion was about 1/4 million dollars. Thus the total cost saving of mechanical harvesting to producers and processors of tomatoes in Virginia was about 3/4 million dollars per season based on 1974 adoption rate and prices.

XXVII. Washington State

a. Extending the harvesting and marketing period for sweet cherries.

Sweet cherry production in Washington for the fresh market has increased from 14,000 tons in the mid-1960's to 33,000 tons in the mid-1970's. The problems involved in harvesting, packing, shipping and marketing this quantity of fresh fruit (3.3 million boxes) in a short ripening season are tremendous. By use of growth regulators, producers were able to extend the harvest season from 10 to 24 days. Research studies on the handling of harvested fruit showed the importance of rapid cooling and bruise prevention and resulting techniques were able to extend the marketing period over a 4-week period. This prevented a disastrous short-term oversupply of fresh cherries reaching markets as had happened previously. Research underway now on using controlled atmospheres storage systems indicate that fresh cherries can be held for months. This would help reduce the wide fluctuations in seasonal price and offer the convenience of a stable supply to consumers.

b. Controlled atmosphere storage of apples stabilizes product marketing.

Washington is the No. 1 State in the production of apples for the fresh market. The single most important research advance was the development of controlled atmosphere storage. Market saturation occurs with resultant drop in price, if more than one million boxes of Washington apples are moved per week. The development of controlled atmosphere storage has doubled the sales volume, increased annual state income to growers by $15 million, and has stabilized employment for fruit industry workers.

c. Quality processed potato products depend upon proper handling and storage techniques of the raw material.

Washington is the No. 2 State in potato production. The bulk of these are processed into flakes, chips, and frozen products such as fries. This requires long-term storage of much of the crop before it can be processed. Researchers have shown the importance of proper handling and storage techniques to prevent bruising and excess sugar buildup, which results in inferior french fries, a major product. Without research on PHT, it is doubtful if Washington's potato industry could have developed to what it is today.

XXVIII. Wyoming

a. Mechanically deboned meat provides consumers a high quality food at a low price.

The scope of the mechanically debonded meat research at the University of Wyoming Agricultural Experiment Station has dealt with the composition, safety and nutritional value of meat which in the past has been wasted because it could not be economically removed from the bone.

The research provides the opportunity for consumers to obtain a supply of the highest quality food at the lowest possible price. It also makes it possible for Wyoming livestock producers to get the highest price for livestock produced. Mechanical deboning makes it possible to obtain 15 pounds of additional meat from each beef animal, 5 pounds of additional meat from each hog and 3 pounds of additional meat from lamb or mutton. In addition to the increased volume of meat, more efficient use of labor should allow the packer to pay the producer more for livestock. The mechanically deboned meat which is being produced at present is competing with meat imports and much mechanically deboned meat is being exported to other countries expanding the market for Wyoming products.

The research at Wyoming has furnished information which has aided in the approval of mechanically deboned meat. The approval allows the greater production of meat and potentially higher prices to the producer. Consumers benefit from mechanically deboned meat because the product is higher in calcium and iron than hand boned meat. Calcium and iron are two minerals which nutritional surveys show are often lacking in the diet.

In the case of mechanically deboned meat, industry has not done the work in the past because the most benefits would be to the consumer and producer. Since industry is often biased by economical considerations, universities should continue post-harvest technology research.

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